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# NUCLEAR SCIENCE ABSTRACTS

## CHEMISTRY

### Analytical Chemistry

*Refer also to abstracts 19744, 19942, and 21330.*

**19620** ANALYTICAL CHEMISTRY OF TRANSURANIUM ELEMENTS. Baeckmann, A. V. (Kernforschungszentrums, Karlsruhe, Ger.). Atompraxis, 15: 15-17(Jan.-Feb. 1969). (In German).

The essential problems in the chemical analysis of the transuranium elements are discussed and the most important methods of analysis are briefly described. (auth)

**19621** SPECTROGRAPHIC DETERMINATION OF METALLIC IMPURITIES IN YTTRIUM USING A SIFTER TYPE ELECTRODE. Kaneko, Keiji; Goseki, Shoichi (Electrotechnical Lab., Tokyo). Bunseki Kagaku, 18: 220-5(Feb. 1969). (In Japanese).

An oxide–direct current excitation method using a sifter type electrode and ammonium bifluoride buffer was applied successfully to the spectrographic determination of B, Fe, Mg, Mn, P, Pb, and Sn in yttrium metals and oxides. Series of standards covering 0.1 to 100 and 1 to 1,000 ppM of the above impurity elements each in four steps (e.g., 0.1, 0.3, 0.7, and 1.0 ppM) were prepared by diluting measured quantities of base materials with weighed quantities (1 to 5 g) of spectroscopically pure yttrium oxides. The spectrographic conditions are as follows: amounts of the oxide, 50 mg; Shimadzu Littrow type spectrograph; excitation voltage, dc 200 V; arc current, 10 amp; slit width, 15 $\mu$; and duration of exposure, 40 sec. Variation coefficients for 0.1 to 1,000 ppM of impurities in yttrium are within 20%. (NSA of Japan)

**19622** SPECTROPHOTOMETRIC DETERMINATION OF BORON IN $U_3O_8$ WITH METHYLENE BLUE. Onishi, Hiroshi; Nagai, Hitoshi (Japan Atomic Energy Research Inst., Ibaraki). Bunseki Kagaku, 18: 164-8(Feb. 1969). (In Japanese).

A spectrophotometric method is described for determination of 0.2 to 1 ppM of B in $U_3O_8$. The sample (1 g) is dissolved by heating with $H_2SO_4$ and $H_2O_2$. Hydrofluoric acid is added to form the tetrafluoroborate ion. Methylene Blue solution is then added, and Methylene Blue tetrafluoroborate is extracted with 1,2-dichloroethane. The organic phase is washed with water to remove the excess dye, and the absorbence of the washed organic phase is measured in a 1-cm cell at 660 m$\mu$. Correction is applied for small amounts of interfering elements (tantalum, etc.) by evaporating the sample solution with hydrofluoric acid (boron is volatilized), adding hydrofluoric acid and Methylene Blue, and extracting with 1,2-dichloroethane. Six analyses of $U_3O_8$ containing 0.5 ppM of B gave a relative standard deviation of 3.2%. The proposed method was successfully applied to several standard $U_3O_8$ samples and a standard U metal. The metal was converted into $U_3O_8$ by igniting at a low temperature and heating at about 800°C for 1 hour. (NSA of Japan)

**19623** USE OF o-IODOBENZOIC ACID AS A REAGENT IN DETERMINING THORIUM. Chang, Juang; Shu, Liang-yao. Acta Sci. Natur. Scholar. Super. Sinens., Chim. Chim.-Tech., 1: No. 1, 11-16(1966). (In Chinese).

2-Iodobenzoic acid, which forms with Th an insoluble compound $Th(OH)(IC_6H_4COO)_3$, is proposed as a reagent in the gravimetric determination of Th. The precipitate is calcinated to $ThO_2$. Optimum value of pH during precipitation is 2.2 to 3.5. The determinable minimum is 0.7 mg of $ThO_2$. A single precipitation is sufficient for the separation of Th from ≤10-fold quantities of rare earth elements (on the basis of oxides). A curve of thermal decomposition of the precipitate was plotted. The formation of $ThO_2$ ends at 700 to 800°. The method was used for determining Th in monazite. The results agree well with those obtained by the benzoate method. (JPRS)

**19624** NEW ANALYTICAL APPLICATIONS OF SOME o-SUBSTITUTED AZOBENZENES. III. SPECTROPHOTOMETRIC DETERMINATION OF MOLYBDENUM WITH 2-(2-HYDROXYPHENYLAZO)PHENOL; APPLICATION TO ANALYSIS OF STAINLESS STEEL. Casassas, E.; Eek, L.; Salvatella, N. (Univ., Barcelona, Spain). Inform. Quim. Anal., Pura Apl. Ind., 21: No. 2, 48-57(1967). (In Spanish).

The extinction of the colored complex formed from 2-(2-hydroxyphenylazo)phenol with Mo in ≃ 50% aqueous ethanol medium containing ≃ 4% of $H_3PO_4$ (pH 1.5 to 2.0) was measured at 500 nm. Beer's law was obeyed from 1 to 16 $\mu$g of Mo/ml. No extraction of the complex was necessary. There was no interference from Cr or Ni, but in the presence of large amounts of Fe a similar amount of Fe should be added to the standard control solution. The procedure for use with stainless steel is described. (Anal. Abstr.)

#### Chemical Procedures

*Refer also to abstract 20564.*

**19625** (NLCO-1030) SIMULTANEOUS DETERMINATION OF IRON AND SILICON IN URANIUM BY AUTO-ANALYSIS. Prall, J. R. (National Lead Co. of Ohio, Cincinnati). Feb. 1969. Contract AT(30-1)-1156. 11p. Dep. CFSTI.

Procedures were developed for the simultaneous automatic colorimetric determination of iron and silicon in uranium. This automated technique is especially suitable for analysis of large numbers of samples. The chromogenic reagent used for the determination of iron is 1, 10-phenanthroline. A molybdenum blue colorimetric procedure is used for the determination of silicon. The sample is dissolved without heating in a mixture of nitric and perchloric acids. After the reaction is complete, dilute hydrofluoric acid is added to completely dissolve the silicon. Flow diagrams are presented for the determination of each element. (auth)

**19626** A SHORT REVIEW ON THE DETERMINATION OF ELEMENTS BY ATOMIC ABSORPTION SPECTROPHOTOMETRY. Panday, V. K.; Ganguly, A. K. (Bhabha Atomic Research Centre, Bombay). Trans. Bose Res. Inst. (Calcutta), 30: 131-45 (Nov. 30, 1967).

A review of the technique of atomic absorption and its application to chemical analysis is presented. The determination of various elements in agricultural, biological, industrial, metallurgical, mining, and petroleum materials is considered. The sensitivity for various elements obtained at Trombay on a Perkin-Elmer AAS are reported. The determination of Ca, Sr, Rb, Mn, Zn, Cu, and Fe in seawater, oysters, environmental air samples, fruit, and human tissue (GI tract, lung, liver, blood) is reported. The detection limits for various elements with a continuous source are also given. (D.H.M.)

**19627** SPECTROPHOTOMETRIC DETERMINATION OF TWO OXIDATION STATES OF MULTIVALENT ELEMENTS. Hais-

sinsky, M.; Raitz, A. (Laboratoire Curie, Paris). Anal. Chim. Acta, 45: 143-7(Mar. 1969). (In French).

Chloroplatinate can be determined in very dilute solutions ($\sim 10^{-5}$ M) spectrophotometrically at 262 nm even in the presence of platinum(II). The latter can be determined at 216 nm only if the concentration of platinum(IV) in the solution is relatively small. Tellurium(IV) can be determined in 4 N hydrochloric acid solution at 250 nm in the presence of tellurium(VI), which can be also determined after extraction of tellurium(IV) by tributyl phosphate and reduction with concentrated hydrochloric acid. (auth)

**19628** SELECTIVE ESTIMATION OF BERYLLIUM WITH MORIN CRAYON ON THE RING OVEN. West, Philip W.; Jungreis, Ervin (Louisiana State Univ., Baton Rouge). Anal. Chim. Acta, 45: 188-90(Mar. 1969).

Determination of beryllium by the ring oven method was investigated in an effort to improve the sensitivity by changing a color reaction to a highly sensitive fluorescence change and to free the method from various interferences. Beryllium ions give an extremely sensitive yellow-green fluorescent product with morin (3,5,7,2'4'-pentahydroxyflavone). Aluminum, thorium, scandium, gallium, and indium ions also give fluorescent inner complexes of similar structure, but a far more important interference was recorded by many heavy metal ions, the presence of which mask the fluorescence of Be with morin. Masking with EDTA proved satisfactory for avoiding the effects of the active interfering group (Al, Th) and also the negative effect of the heavy metal group. EDTA reacts with most metal ions, including Be, to produce water-soluble chelates compounds, with inner complex anions. These products are resistant to ammonia, except for the Be–EDTA complex, which decomposes in ammonia forming $Be(OH)_2$, which successively forms a green-yellow fluorescent product with morin. The exceptional instability of the Be–EDTA complex is the basis of a highly selective determination whose lower detection limit is 0.01 μg and upper detection limit is 0.2 μg of Be. (D.H.M.)

**19629** DETERMINATION OF TRACES OF HYDROGEN, NITROGEN, AND OXYGEN IN AQUEOUS SOLUTIONS BY GAS CHROMATOGRAPHY. Tolk, A.; Lingerak, W. A.; Kout, A.; Boerger, D. (Reactor Centrum Nederland, Petten, Netherlands). Anal. Chim. Acta, 45: 137-42(Mar. 1969).

Traces of hydrogen, nitrogen, and oxygen in water can be determined by stripping the gases from water samples of up to 30 ml with a helium stream. The stripped gases are absorbed from the helium on molecular sieve 5A pellets at liquid nitrogen temperature; at room temperature, the gases are desorbed from the molecular sieve and determined by gas chromatography. Carbon monoxide, methane, and argon can be determined simultaneously. (auth)

**19630** DETERMINATION OF PHOSPHORUS, ARSENIC, OR SILICON BY ATOMIC ABSORPTION SPECTROMETRY OF MOLYBDENUM HETEROPOLY ACIDS. Ramakrishna, T. V.; Robinson, J. W.; West, Philip W. (Louisiana State Univ., Baton Rouge). Anal. Chim. Acta, 45: 43-9(Mar. 1969).

A method is described for the determination of trace amounts of phosphorus, arsenic, or silicon by atomic absorption spectrometry. The heteropoly-molybdo acids of phosphorus, arsenic, and silicon were formed and selectively separated by means of solvent extraction, and the molybdenum present in the organic phase was determined by atomic absorption spectroscopy with a nitrous oxide–acetylene flame. The method is rapid, simple, and accurate and is essentially free from interferences. (auth)

**19631** SPECTROPHOTOMETRIC DETERMINATION OF EUROPIUM(II). Gromova, M. I.; Litvina, M. N.; Peshkova, V. M. Vestn. Mosk. Univ., Ser. II. Khim., No. 1, 30-4(Jan.-Feb. 1969). (In Russian).

The absorption spectra of $EuCl_2$ solution were studied and extinction coefficients in maxima were calculated ($\epsilon_{\gamma 248} = 1213 \pm 36$, $\epsilon_{\gamma 328} = 429 \pm 12$). The spectrophotometric determination of Eu(II) in concentration range 0.04 to 0.86 mg was carried out. A new variety of differential spectrophotometric method for determination of europium based on preliminary reduction of Eu in $Sm_2O_3$ and $Gd_2O_3$ is suggested, the europium content being ~0.1%. (auth)

**19632** PHOTOMETRIC DETERMINATION OF URANIUM IN THE ORES BY 4-(2-THIAZOLYLAZO)-RESORCINOL. Busev, A. I.; Ivanov, V. M. Vestn. Mosk. Univ., Ser. II. Khim., No. 1, 103-5(Jan.-Feb. 1969). (In Russian).

A method for the photometric determination of uranium(VI) (0.04 to 0.33%) in ores was developed. (auth)

**19633** DETERMINATION OF THE $^{137}Cs$ CONTENT OF THE MILK IN VARIOUS REGIONS OF ROMANIA. Furnica, G.; Marseu, P.; Cojocaru, T. M.; Dumitru, G. (Institutul de Igiena, Bucharest). Lucr. Stiint., Inst. Agron. N. Balescu, Bucuresti, Ser. C, 9: 561-7(1966-7). (In Rumanian).

Cesium-137 content in milk was studied in the following regions of Romania: Brasov, Constanta, Oradea, Arad, Sinaia, Satu-Mare, Vatra-Dornei, Pitesti, Cluj, Craiova, Tg. Mures, Remetea, Bucharest, Rarau, Galati, Bacau, Suceava, and Ploiesti. For the determination of the $^{137}Cs$ content in the ashed residue of milk, the γ-spectrometric method was used. The results showed wide variations, from 1.6 to 94.4 pCi $^{137}Cs$ per g ash. The radioactivity was highest in the Bacau, Bucharest, Jassy, and Remetea regions. (BBB)

**19634** ANALYSIS OF ISOTOPIC RADIUM IN THORIUM MILL EFFLUENTS. Kamath, V. A.; Parekh, P. P. (Bhabha Atomic Research Centre, Bombay). Talanta, 16: 345-50(Mar. 1969).

A simple and rapid method was developed for the determination of isotopic radium, based on γ-ray spectrometry. $^{228}Ra$ and $^{224}Ra$ are assayed by measuring the intensities of the photo-peaks in the 0.94 and the 2.62 MeV regions of the γ-spectrum. The interference in these measurements arising from the presence of the $^{226}Ra$–$^{210}Pb$ chain in the sample is obviated by the almost complete expulsion of $^{222}Rn$ from the system. The precision of the method is ±2% and ±3% in the determination of $^{228}Ra$ and $^{224}Ra$, respectively, the absolute sensitivities being 2 and 0.5 nCi. The method was applied to evaluate the distribution of these isotopes in the various products of the Indian Rare-Earths Factory, Alwaye. (auth) (UK)

**19635** SELECTION OF EXCITING ENERGY IN RADIOISOTOPE X-RAY FLUORESCENCE ANALYSIS. Carr-Brion, K. G. (Warren Spring Lab., Stevenage, Eng.). Analyst, 94: 177-81(Mar. 1969).

The use of excited x-rays with energies either just above or far above the x-ray absorption edge of the wanted element has been proposed for radioisotope x-ray fluorescence analysis. The performance of these two methods is compared in terms of limits of detection, reduction of heterogeneity effects, and compensation for matrix effects. (auth) (UK)

**19636** SPECTROPHOTOMETRIC DETERMINATION OF NIOBIUM IN STEEL WITH SULFOCHLOROPHENOL S. Wakamatsu, Shigeo (Topy Industries, Ltd., Tokyo). Bunseki Kagaku, 18: 376-83(Mar. 1969). (In Japanese).

A new simple and reliable method was presented for the spectrophotometric determination of 0.01 to 4% of niobium in steel. The sample is decomposed with HCl, $HNO_3$, and $HClO_4$, and niobium is separated from common interfering elements such as iron, molybdenum, tungsten, and vanadium by precipitation with phytin. The precipitate is decomposed with $HNO_3$, $HClO_4$, and $H_2SO_4$, and then determined photometrically by Sulfochlorophenol S method which is based on the reaction of niobium with Sulfochlorophenol S to form a blue complex. The method obeys Beer's law and is sensitive for niobium ranging from 4 to 40 μg. Zirconium is the only ion that interferes seriously but can be masked with EDTA. (auth)

**19637** DETERMINATION OF SMALL AMOUNTS OF HAFNIUM IN ZIRCONIUM ALLOYS BY FLUORESCENT X-RAY SPECTROSCOPY. Ohno, Katsumi; Matano, Nobuhisa (National Research Inst. for Metals, Tokyo). Bunseki Kagaku, 18: 213-19 (Feb. 1969). (In Japanese).

Analytical conditions for the x ray fluorescence determination of small amounts of hafnium in zirconium alloys were examined. The best result was obtained by using $HfL_\beta$ as the analytical line and an x-ray tube with a gold target. The interference from the ZrK line was removed by a yttrium filter, giving the best result with combined use of pulse-height analyzer. The limit of detection of Hf was ca. 7 ppM. The standard deviation for the determination of 50 to 500 ppM Hf in zirconium alloys was 5 ppM. The relation of the sort of target metals in the x-ray tube and the limit of detection of hafnium, together with the limit of detection and the error in the calibration line, were also examined. (NSA of Japan)

**19638** EXTRACTION-PHOTOMETRIC DETERMINATION OF NIOBIUM IN ZIRCONIUM MINERALS USING LUMOGALLION. Konusova, V. V.; Opochanskaya, L. D.; Tsykhanskii, V. D. (Inst. of Geochemistry, Irkutsk, USSR). Zh. Anal. Chim., 24: 400-3(Mar. 1969). (In Russian).

The possibility of using lumogallion (2,2',4-trihydroxy-5-chloro-(1-azo-1')-benzene-3-sulfonic acid) for the determination of niobium in zirconium minerals is reported. An extraction-photometric method has been developed for determining

niobium in small samples of the mineral. The sensitivity of the method is 0.1 μg/ml of niobium, the mean square relative error is 2 to 4%. (auth)

**19639** USE OF SUSPENSION OF ROCKS AND MINERALS IN THE METHOD OF FLAME SPECTROPHOTOMETRY. Lebedev, V. I. (Inst. of Geochemistry and Analytical Chemistry, Moscow). Zh. Anal. Khim., 24: 337-41(Mar. 1969). (In Russian).

A new method is suggested for introducing samples of rocks and minerals into a flame used for exciting and atomizing. The method suggested permits, in particular, the determination of alkaline metals with an accuracy comparable to that of the ordinary methods of flame spectrophotometry without special changes on the apparatus. By introducing rocks into the flame as a suspension the chemical treatment of the samples is completely eliminated, and thus the analysis becomes more rapid. (auth)

**19640** A METHOD OF THE LAYER MASS-SPECTROGRAPHIC ANALYSIS. COMMUNICATION I. ANALYSIS OF SMALL VOLUMES OF SUBSTANCES AND THIN SEMICONDUCTING FILMS. Chupakhin, M. S.; Ramendik, G. I.; Kryuchkova, O. I. (Inst. of Geochemistry and Analytical Chemistry, Moscow). Zh. Anal. Khim., 24: 352-7(Mar. 1969). (In Russian).

The possibilities of using physical methods for the analysis of layers and local analysis of substances of high purity are discussed. A mass spectrographic layer method has been developed for studying the distribution of impurities in thin layers of substance to the depth of about 10 μ with a sensitivity of down to $10^{-5}$%. Data are given for the determination of Na, Mg, Al, Si, S, Cl, K, Ca, Ti, V, Cr, Mn, Cu, Zn, Nb, Mo, In, Ta, and W in Re layers. (P.C.H.)

**19641** EXTRACTION-PHOTOMETRIC AND EXTRACTION-FLUORIMETRIC DETERMINATION OF SCANDIUM AS A MORIN–ANTIPYRINE COMPLEX. Nazarenko, V. A.; Antonovich, V. P. (Inst. of General and Inorganic Chemistry, Odessa). Zh. Anal. Khim., 24: 358-61(Mar. 1969). (In Russian).

In the presence of strong acid anions, the best of which is a perchlorate ion, scandium forms an extractable complex with morin and antipyrine at a molar ratio of Sc : morin : antipyrine : $ClO_4^-$ = 1 : 1 : 3 : 1. With this complex it is possible to determine 0.1 μg/ml of scandium photometrically and 0.01 μg/ml of scandium fluorimetrically. Aluminum, gallium, indium, titanium, thorium, zirconium, and lutetium interfere in the scandium determination. No interference is caused by the presence of rare earths of the cerium subgroup. (auth)

**19642** SEPARATE AND SIMULTANEOUS DETERMINATION OF ZIRCONIUM AND HAFNIUM IN NICKEL-BASE ALLOYS WITH XYLENOL ORANGE. Challis, H. J. G. (International Nickel Ltd., Birmingham, Eng.). Analyst, 94: 94-104(Feb. 1969).

The use of xylenol orange as a spectrophotometric reagent for zirconium and hafnium was investigated for their determination, in the range 0.002 to 0.2 per cent in complex nickel-base alloys, and the effects of major alloying elements, and likely impurities, were studied. A simple, direct procedure, based on the formation of the red xylenol orange complexes in 0.8 N hydrochloric acid, was successfully applied to the determination of either metal in nickel alloys containing chromium, cobalt, iron, molybdenum, titanium, and aluminum. For alloys containing both zirconium and hafnium, a procedure developed for their simultaneous determination is based on the relative effect of acid concentration on the xylenol orange complexes. Preliminary mercury cathode and hydroxide separations are followed by measurement of the total optical densities at three levels of acidity, 0.35, 1.12, and 2.0 N perchloric acid. This "three-point" method has proved satisfactory with synthetic alloy solutions and when applied to complex nickel alloys containing both zirconium and hafnium. Confirmatory evidence of the results was obtained by x-ray fluorescence and emission and mass spectrometry. The simultaneous procedure provides a simple and sensitive chemical method for differentiating between microgram amounts of zirconium and hafnium, and should be capable of wider application to other alloy systems. The simpler direct method should also prove advantageous when mutual interference does not arise. (auth) (UK)

**19643** THE SPECTROFLUORIMETRIC DETERMINATION OF EUROPIUM AND TERBIUM. Belcher, R.; Perry, R.; Stephen, W. I. (Univ. of Birmingham, Eng.). Analyst, 94: 26-31 (Jan. 1969).

The fluorescent properties of the tris chelates of europium and various β-diketones were examined. Fluorinated ligands give better sensitivity than unfluorinated ligands, but the best sensitivity was found with 2-thenoyltrifluoroacetone in dimethylformamide. A rapid method for the determination of $10^{-7}$ to $10^{-3}$ M europium(III) is discussed. Both europium and terbium can be readily determined in the $10^{-2}$ to $10^{-3}$ M range by measuring the fluorescence of the complexes formed with dimethylformamide alone. (auth) (UK)

**19644** METHOD AND APPARATUS FOR AUTOMATIC NEUTRON ACTIVATION ANALYSIS COMPRISING SIMULTANEOUS ROTATION OF A KNOWN AND AN UNKNOWN SAMPLE. Jones, Robert E. Jr.; Price, Harold J. (to Kaman Corp.). U. S. Patent 3,431,416. Mar. 4, 1969. Filed Dec. 9, 1964.

The method and apparatus for automatic neutron activation analysis are described. The apparatus provides for the simultaneous rotation of a known and an unknown sample each about two axes wherein the two axes of rotation of each sample are of non-coplanar relation during irradiation to provide for the uniform irradiation of both the known and unknown sample. (Offic. Gaz.)

**19645** DETERMINATION OF IMPURITIES IN METALLIC NIOBIUM. I. ABSORPTIOMETRIC DETERMINATION OF MOLYBDENUM AND TUNGSTEN WITH TOLUENE-3,4-DITHIOL. Stashkova, N. V.; Kurbatova, V. I. Tr. Vses. Nauch.-Issled. Inst. Stand. Obraztsov Spektr. Etalonov, 2: 10-14(1965). (In Russian).

Molybdenum is determined in metallic Nb by dissolving a 0.5 g sample by heating with 10 ml of concentrated $H_2SO_4$ and 2 g of $(NH_4)_2SO_4$, cooling the solution to 20 to 25°C, adding 10 ml of HF (1 : 4), again heating, then cooling, adding 25 ml of HCl (1 : 2) containing 1 ml of 1% alkaline toluene-3,4-dithiol(I) solution, aging the complex for 30 min with occasional agitation, extracting the complex into 5 ml of $CCl_4$ by shaking for 2 min, and measuring the extinction of the extract at 670 to 680 mμ vs a blank. Tungsten is determined in the aqueous phase from the $CCl_4$ extraction by evaporating the aqueous phase to fumes; washing down the sides of the flask with $H_2O$; again evaporating; cooling the solution; adding 10 ml of HF (1 : 4), 25 ml of dilute HCl, and 10 ml of 1% $Ti_2(SO_4)_3$ solution; heating on a water bath to 80 to 90°C for 10 min to reduce W(VI) to W(V); adding 1 ml of 1% alkaline solution of I; heating for an additional 20 min; cooling; extracting the W(V)–I complex by shaking for 2 min with 5 ml of $CCl_4$; and measuring the extinction of the extract at 630 to 640 mμ vs a blank solution. (Anal. Abstr.).

**19646** RUTHERFORD SCATTERING AND CHANNELING: A USEFUL COMBINATION FOR CHEMICAL ANALYSIS OF SURFACES. Mackintosh, W. D.; Davies, J. A. (Atomic Energy of Canada Ltd., Chalk River). Anal. Chem., 41: 26A-35A(Apr. 1969).

Elastic scattering yields can give valuable information not only on the number of impurity atoms in the crystal surface but also on their lattice location within the unit cell. Channeling enhances considerably the sensitivity of the analysis, particularly in the case of low-mass impurities. A review of the theory and practice of the elastic scattering method and a description of how channeling can be of use to the chemical analyst are presented. (D.H.M.)

**19647** CATION EXCHANGE SEPARATION: X-RAY SPECTROMETRIC DETERMINATION OF SCANDIUM IN PLUTONIUM. Hakkila, E. Arnold; Hurley, Ronald G.; Waterbury, Glenn R. (Los Alamos Scientific Lab., N. Mex.). Anal. Chem., 41: 665-7(Apr. 1969).

A method for the determination of scandium present in concentrations between 0.05 and 0.4% in alloys with plutonium by x-ray fluorescence and ion exchange is presented. Cation exchange filter papers were used to remove scandium from plutonium(VI) solutions in hydrochloric acid–organic solvent media. Greater than 50 μg of Cs, 100 μg of Nd, 500 μg of Pt, and 100 μg of Ce interfere in the determination. The relative standard deviation of the method was approximately 2% for determining 50 to 400 μg of Sc. The lower limit of reliability was approximately 0.5 μg of Sc. (D.H.M.)

**19648** A RAPID AND SELECTIVE METHOD FOR THE SPECTROPHOTOMETRIC DETERMINATION OF NIOBIUM. Villarreal, Robert; Barker, Spence A. (Argonne National Lab., Idaho Falls, Idaho). Anal. Chem., 41: 611-13(Apr. 1969).

A rapid and selective method for the separation and determination of niobium in uranium–fissium alloy was developed. The procedure is based on the extraction into toluene of niobium with N-benzoyl-N-phenylhydroxylamine (BPHA) from 9 to 12M HCl containing stannous chloride. The Nb–BPHA complex in toluene is contacted with ammonium thiocyanate in 4M HCl and the color intensity of the Nb–BPHA–SCN complex in toluene is measured at 365 mμ. Of 48 elements tested, only tantalum interferes at all levels. Milligram quantities of tartrate, oxalate, citrate, fluoride and other common anions do not interfere; hydrogen peroxide interferes but is easily destroyed. The ionic molar absorptivity of the colored complex measured under the conditions of the proce-

dure is 32,000. Beer's law is obeyed from 0 to 50 μg Nb. At the 0.01% niobium level in uranium–fissium alloy, the relative precision of the method is ±2%. (auth)

**19649** A REVIEW OF THE CHEMICAL ANALYSES REQUIRED FOR THE OPERATIONAL CONTROL OF A $^{15}N$ PLANT BASED ON THE CHEMICAL EXCHANGE BETWEEN NITRIC ACID AND NITROGEN OXIDE. Axente, D. Rev. Chim. (Bucharest), 19: 671-4(Nov. 1968). (In Rumanian).

The stable $^{15}N$ isotope, found at a concentration of 0.365% in natural nitrogen gas, may be enriched by the isotopic exchange reaction, $^{15}N + H\,^{14}NO_3 \rightleftharpoons {}^{14}NO + H\,^{15}NO_3$, using a refluxing column. Operational control requires the chemical determination of the nitrogen oxides, nitric and sulfuric acids and the isotopic analysis of the $^{15}N$ in the nitric acid and the nitrogen oxides. In order to minimize corrosion, the nitric acid and nitrogen oxides must be transformed into elemental nitrogen before introducing the samples into the mass spectrograph. The $H\,^{15}NO_3$ from the column is reduced to ammonia and captured in a hydrochloric or sulfuric acid solution. The ammonium salts may be decomposed by CaO or sublimation over CuO or NiO. For the isotopic analysis, the mixture of nitrogen oxides is passed over CuO at 700 to 750°C in a quartz tube; Armco iron was also used with success. The method used to determine the gas mixture leaving the reflux column depends on the relative concentration of $NO_2$ and NO; colorimetric methods were found useful for this analysis. (TTT)

**19650** MASSENSPEKTROMETRIE. (Mass Spectrometry). Brunnee, C.; Voshage, H. Munich, Verlag Karl Thiemig KG, 1964. 326p.

Topics covered include: physical principles, mass separation, ion production, sample supplies, ion detection, construction of mass spectrometers, isotopic abundance determinations, precision mass determinations, quantitative analysis, qualitative analysis, physicochemical investigations, and investigations of the interaction of ions with matter. (M.C.G.)

**19651** THE CONVERSION OF HYDROGEN COMPOUNDS TO HYDROGEN IN CLOSED TUBES FOR PRECISION MASS-SPECTROMETRIC ANALYSIS OF DEUTERIUM IN THE RANGE OF NATURAL VARIATION. Rolle, W.; Bigl, F.; Haase, G.; Runge, A.; Huebner, H. (Institut fuer Stabile Isotope, Leipzig). Isotopenpraxis, 5: 35-6(Jan. 1969). (In German).

Reactions for conversions of pure water with zinc, or water or organic compounds with chromium are described. After conversion of the hydrogen in the compound to hydrogen gas; the deuterium in the hydrogen could be determined by mass spectroscopy. (M.C.G.)

**19652** ANALITICHESKAYA KHIMIYA PROTAKTINIYA. (Analytical Chemistry of Protactinium). Pal'shin, E. S.; Myasoedov, B. F.; Davydov, A. V. Analiticheskaya Khimiya Elementov. (Analytical Chemistry of Elements). Moscow, Izdatel'stvo Nauka, 1968. 240p.

A brief review is given on protactinium isotopes including valency, structure, and toxic properties. The second chapter covers chemical properties and methods of analysis of protactinium compounds. Methods of determining protactinium are described in the third and fourth chapters; and separation from impurities by precipitation, extraction, chromatographic, and electrochemical methods is discussed in the last chapter. (708 references). (R.V.J.)

**19653** THE DETERMINATION OF MOLYBDENUM IN MIXTURES CONTAINING MOLYBDENUM DISULPHIDE BY ATOMIC ABSORPTION SPECTROPHOTOMETRY. Julietti, R. J.; Wilkinson, J. A. E. (Morganite Research and Development Ltd., London). Analyst, 93: 797-8(Dec. 1968).

A rapid method is described for determining the total molybdenum content of mixtures containing molybdenum disulfide, graphite, and a resin. The novel feature of the technique is the decomposition of the mixture by fusion with sodium hydroxide. Dissolution of the melt in sulfuric acid permits the determination of molybdenum by atomic absorption spectrophotometry without interference. Results at the 8% molybdenum level are accurate to within ±0.1%. (auth) (UK)

**19654** THE DETERMINATION OF ZIRCONIUM IN MINERAL RUTILE WITH ALIZARIN RED S. Stanton, N. B. (Associated Minerals Consolidated Ltd., Southport, Australia). Analyst, 93: 802-4(Dec. 1968).

A colorimetric procedure was developed for the determination of the zirconium oxide content of rutile. A fusion with potassium hydrogen difluoride enables the rutile to be brought into solution rapidly and eliminates the task of filtering off silica. The zirconium is separated from the titanium by a phosphate precipitation, but the interference of tin inherent in the method involving phosphate precipitation followed by ignition to oxide, is eliminated by dissolving the zirconium phosphate and applying a colorimetric finish, with Alizarin red S. Calibration is effected by making additions of zircon to titanium oxide and carrying each through the entire procedure, thus eliminating reagent-blank difficulties. The method was used in the range of 0 to 1% of zirconium oxide. Good agreement with independent determinations by x-ray fluorescence was obtained. (auth) (UK)

**19655** THE SPECTROPHOTOMETRIC DETERMINATION OF THORIUM(IV) WITH BROMOPYROGALLOL RED. Tonosaki, Koichi (Hirosaki Univ., Japan); Sakai, Takayoshi. Bull. Chem. Soc. Jap., 42: 456-9(Feb. 1969).

Bromopyrogallol red reacts with thorium(IV) to form a stable complex with an absorption maximum at 645 mμ against a reagent blank. The maximum absorbance is obtained in the pH range of 5.6 to 5.9 when the solution is heated in a boiling water bath for 20 min. The color system obeys Beer's law in the range 6 to 106 μg of thorium in 25 ml. The molar absorptivity of the complex is calculated to be $5.0 \times 10^4$ at 645 mμ. The sensitivity of the reaction is 0.004 μg thorium per $cm^2$. The complex has the composition 1 to 2 in metal to ligand. The effects of diverse ions on the determination were examined. (auth)

**19656** REACTIONS OF $UO_2^{2+}$ WITH PHLOROGLUCINOL CARBOXYLIC ACID. Horak, J.; Kratka, M. (Purkyne Univ., Brno). Collect. Czech. Chem. Commun., 34: 395-406(Feb. 1969). (In German).

By means of a spectrophotometric investigation of the reaction of uranyl salts with 2,4,6-trihydroxybenzoic acid in aqueous solutions, a stepwise formation of complexes with component ratios $UO_2^{2+}$ : R of 1 : 1 and 1 : 2, depending on the pH of the solution and component concentration, was established. The reaction is suitable for photometric determination of uranium. (tr-auth)

**19657** COMPLEXES OF MALTOL WITH URANYL AND ALUMINUM. Chiacchierini, E.; Bartusek, M. (Univ. of Rome. Purkyne Univ., Brno). Collect. Czech. Chem. Commun., 34: 530-6(Feb. 1969).

Complexes of maltol with uranyl and aluminum were studied potentiometrically in dilute aqueous solutions containing excess reagent. The formation of the complexes with ratios M : R of 1 : 1; 1 : 2; and 1 : 3 was proved in acidic and neutral solutions. (auth)

## *Isotopic Procedures*

**19658** (BNWL-CC-669) EVALUATION OF ISOTOPIC DILUTION METHOD USED FOR DESTRUCTIVE ANALYSIS OF IRRADIATED FUELS. Matsen, R. P. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). [nd]. Contract AT(45-1)-1830. 14p. Dep. CFSTI.

Twenty-seven samples cut from three rods of a conventional 19-rod PRTR cluster were destructively analyzed for uranium content and Pu/U ratios by two independent techniques. The first involved alpha counting and gravimetric methods. The second used isotope dilution techniques. Values obtained by the two methods are compared. The plutonium content was given accurately by either method, but further effort is needed to obtain more reliable uranium values. (M.C.G.)

**19659** DETERMINATION OF THE CONCENTRATION OF TRANSURANIUM ISOTOPES. Koch, L. (EURATOM, Karlsruhe, Ger.). Atompraxis, 15: 27-9(Jan.-Feb. 1969). (In German).

The applications of and limitations to isotope dilution analysis by alpha and mass spectrometry in determination of long-lived transuranium isotopes formed in a reactor are described. (auth)

**19660** QUANTITATIVE ASPECTS OF NUCLEAR QUADRUPOLE RESONANCE SPECTROMETRY OF INORGANICS AND MINERALS. Schultz, Harry D.; Karr, Clarence Jr. (Morgantown Coal Research Center, W. Va.). Anal. Chem., 41: 661-4(Apr. 1969).

Quantitative nuclear quadrupole resonance (NQR) spectrometric analyses of synthetic mixtures and natural ores are presented, apparently for the first time. Reproducible linear quantitative calibration curves were obtained on several inorganic compounds ($Cu_2O$, $HgCl_2$, $BiCl_3$), using the signals from $^{63}Cu$, $^{65}Cu$, $^{35}Cl$, and $^{209}Bi$. Synthetic mixtures of $HgCl_2$ in NaCl, and $BiCl_3$ in KCl, were analyzed by NQR for weight-% $HgCl_2$ and $BiCl_3$, respectively, with good results. In addition, several samples of cuprite ore were analyzed for weight-% of $Cu_2O$ from the standard curves. Noted were the influence of various instrument parameters and the physical state of the sample on quantitative NQR spectrometry. (auth)

## Radiometric Procedures

*Refer also to abstracts 19658 and 19908.*

**19661** (STI/DOC-10/95) QUICK METHODS FOR RADIOCHEMICAL ANALYSIS. Technical Reports Series No. 95. (International Atomic Energy Agency, Vienna (Austria)). Feb. 1969. 63p. Dep. IAEA: $2.00; Austrian Schillings 52,-; £ 0.16.9; F Fr. 9,80; DM 8,-.

Methods for determining $^{137}Cs$ in water, milk, and urine; $^{131}I$ in waste waters, milk, rainwater, and urine; $^{32}P$ in urine; Pu in waste water, urine, and various matrices; $^{85}Sr$ and $^{90}Sr$ in water and urine; beta activity in water; and alpha activity in urine are presented. (D.H.M.)

**19662** INVESTIGATION INTO THE ELASTIC pd-SCATTERING BY THE THIN INTERNAL TARGET METHOD. Hristov, L.; Kanazirski, H.; Zajacki, V.; Jovcev, K. God. Vissh. Tekh. Ucheb. Zaved., Fiz., 3: No. 1, 109-14(1966-67). (In Russian).

The possibility of determining the deuterium content in a deuterated polyethylene target was explored. Results of the elastic pd scattering investigation of the deuterated target are compared with results from pp scattering by a polyethylene target. (Abstr. of Bulg. Sci. Lit.)

**19663** ESTIMATION OF TANTALUM IN STAINLESS STEEL BY X-RAY FLUORESCENCE. Portafaix, M. R. Method. Phys. Anal., 4: 170-3(June 1968). (In French).

The austenitical stainless steels stabilized by niobium have, in general, a low tantalum ratio coming from the ferroniobium used for steel elaboration. Since classical chemical methods permit the total titration of tantalum and niobium, an x-ray fluorescence spectrometric method for titrating Ta was investigated, involving the separation of tantalum and niobium by chemical means in the pentoxide state. The precipitate obtained was dissolved in tartaric solution and the solution compared by x-ray fluorescence spectrometry with a synthetic standard solution. The efficiency of the chemical separation was evaluated and the method was used to titrate standard samples in order to carry out tantalum titration by x-ray fluorescence by directly irradiating steel samples. (auth)

**19664** RESOLUTION OF $^{90}Sr$ AND $^{89}Sr$ NUCLIDES BY MEASURING THEIR ACTIVITY. PART I. Santholzer, V.; Stransky, P.; Knaifl, J.; Kuncova, V. Jad. Energ., 14: 417-19 (1968). (In Czech).

It is possible to determine the amount of $^{90}Sr$ and $^{89}Sr$ by measurement of the beta activity for increasing contents of $^{90}Y$ and decomposition of $^{89}Sr$. Measurements can be made on standard mixtures or on the fraction of strontium isolated from atmospheric precipitation shortly after nuclear weapons tests. It is necessary to know the efficiency of the Geiger–Mueller counter for beta particles from $^{90}Sr$ and $^{90}Y$. It is possible to calculate the amounts of $^{90}Sr$ and $^{89}Sr$ on the basis of simple equations. (tr-auth)

**19665** DETERMINATION OF $^{137}Cs$ IN FAST-REACTOR COOLANT SYSTEMS. Oldham, G.; Ware, A. R.; Sykes, D. J. (Univ. of Tech., Loughborough, Eng.). Talanta, 16: 430-2 (Mar. 1969).

A method for the separation of caesium by ion exchange involving ammonium 12-molybdophosphate was investigated, and found to be 100% efficient for aqueous solutions with high sodium and potassium concentrations. (auth) (UK)

**19666** METHOD OF QUANTITATIVE ANALYSIS OF REDUCIBLE SUBSTANCES WITH HYDRATED ELECTRONS. Hart, Edwin J.; Fielden, Edward M (to Atomic Energy Commission). U. S. Patent 3,429,667. Feb. 25, 1969. Filed May 2, 1966.

A method of analyzing an aqueous solution for a very small quantity of a reducible substance is described. The solution, having a pH of 11 to 12 and saturated with hydrogen, is irradiated with a low-intensity pulse of radiation capable of producing hydrated electrons. A beam of light is passed through the solution, and the change in transmission of the light as the hydrated electrons decay is compared with a standard. (TSS) (Offic. Gaz.)

**19667** ANALYSIS BY NUCLEAR REACTIONS FOR OXYGEN AND CARBON IN A THIN LAYER ON THE SURFACE OF METALS. PRECAUTIONS TO TAKE DURING MEASUREMENTS ON SOLID CARBON TARGETS. Quaglia, L. (Univ., Liege); Robaye, G.; Cuypers, M.; Barrandon, J. N. Nucl. Instrum. Methods, 68: 315-24(1969). (In French).

A preliminary study was made to define valid experimental conditions for determining the quantity of oxygen and carbon, retained by adsorption or chemical reaction, on the surface of high-purity metals. A method of analysis by charged-particle nuclear reactions was applied. The first experimental results are given for aluminum metal. These results were compared to those obtained for the same samples, using the activation analysis technique with 2-MeV tritons. (auth)

**19668** A MODIFIED MICROCOMBUSTION METHOD FOR THE DETERMINATION OF TRITIUM IN ORGANIC MATERIAL. Maurer, H. Rainer (Deutsche Krebsforschungszentrum, Heidelberg). Z. Physiol. Chem., 349: 115-17(Jan. 1968). (In German).

A modification of the in-vial combustion method of Gupta (Gupta, G. N., Analyt. Chem., 38: 1356(1966)) for assay of tritium in organic materials (up to 7 mg dry weight) is described. The methodological improvements concern the platinum combustion stand, the lens paper, and the liquid scintillator. The loss of counting efficiency by $H_2O$- and $O_2$-quenching amounts to only 6% on the average. Several conditions are described that must be observed to maintain the reproducibility of the method (±1.6 to 2.2% s.d.). The tritium counting efficiency attainable is 25%. (auth)

**19669** A SIMPLIFIED PROCEDURE FOR THE ASSAY OF PICOCURIE CONCENTRATIONS OF $^{226}Ra$ AND ITS APPLICATION TO A STUDY OF THE NATURAL RADIOACTIVITY IN SURFACE WATERS IN SCOTLAND. Conlan, B.; Henderson, P.; Walton, A. (Univ. of Glasgow). Analyst, 94: 15-19(Jan. 1969).

A simplified emanation system for measuring picocurie concentrations of radium-226 is described. A scintillation detector, fabricated from Perspex, and standard commercial electronics are used. Efficiencies of 55 per cent were obtained with backgrounds of about 1 count per minute for several detectors. Studies were conducted of the natural radioactivity in Loch Lomond and surrounding streams. The Loch surface water was found to have an average radium-226 concentration of 0.04 pCi $l^{-1}$ and the uranium concentration, as determined by delayed neutron technique, was 0.13 $\mu g\ l^{-1}$. These results suggest that the amounts of radium-226 in the oceans are independent of the influx from streams, and that drinking water in this region of Scotland does not constitute a significant intake of radium-226 by humans. (auth)

**19670** RADIOMETRIC ACID-BASE TITRATIONS. Erdey, L.; Gimesi, O.; Szabadvary, F. (Technical Univ., Budapest). Talanta, 16: 445-7(Mar. 1969).

Acid-base titrations can be performed with radiometric endpoint detection by use of labelled metal salts (e.g., $ZnCl_2$, $HgCl_2$). Owing to the formation or dissolution of the corresponding hydroxide after the equivalence point, the activity of the titrated solution linearly increases or decreases as excess of standard solution is added. The titration end-point is determined graphically. (auth) (UK)

**19671** RADIOCHEMICAL DETERMINATION OF $^{99}Tc$ IN ENVIRONMENTAL WATER SAMPLES. Golchert, Norbert W.; Sedlet, Jacob (Argonne National Lab., Ill.). Anal. Chem., 41: 669-71(Apr. 1969).

A radiochemical procedure is presented for the determination of $^{99}Tc$, a pure beta emitter (0.29 MeV maximum energy) with a half-life of $2.12 \times 10^5$ years, at levels as low as 0.5 dpm per liter of water. The samples are evaporated from a NaOH solution and the ruthenium precipitated as ruthenium dioxide. Further decontamination is provided by iron scavenging. Since copper sulfide will carry Te(VII) quantitatively, it was precipitated from HCl and then dissolved in 50% hydrogen peroxide in 1 $\underline{N}$ $H_2SO_4$. Pertechnetate was extracted into 5% triisooctylamine in xylene solution and the Tc was then back-extracted with NaOH. The Tc was electrodeposited from NaOH onto stainless steel and beta counted. For a 1000-min count the limit of detection was 0.5 pCi ($2.7 \times 10^{-11}$ g)/l at the 99% confidence level. Decontamination factors for the technetium procedure are given for $^{54}Mn$, $^{60}Co$, $^{65}Zn$, $^{90}Sr - ^{90}Y$, $^{95}Zr - ^{95}Nb$, $^{106}Ru - ^{106}Rh$, $^{125}Sb$, $^{131}I$, $^{137}Cs$, $^{144}Ce$, $^{233}U$, and $^{239}Pu$. (D.H.M.)

**19672** IMPROVED RESOLUTION IN HIGH-SENSITIVITY DUAL-LABEL GAS RADIOCHROMATOGRAPHY. Thomas, Paul J.; Dutton, H. J. (Northern Regional Research Lab., Peoria, Ill.). Anal. Chem., 41: 657-60(Apr. 1969).

The simultaneous and independent measurement of $^{14}C$ and tritium isotopes in compounds separated by gas–liquid chromatography can be performed by automatic serial collection of fractions in vials with subsequent scintillation counting. Digital computer techniques are described that speed the analysis of counting data, improve the sensitivity and resolution of the analysis, and plot the individual isotopic curves. This improvement is obtained by combining and averaging the results of two to four replicate analyses

of a given sample into a single plot of radioactivity vs chromatographic retention time. With these techniques, samples having an activity of around 1 to 10 nanocuries/mg can be easily analyzed. The profile of radioactivity vs chromatographic retention time is superior in its signal-to-noise-ratio, in its resolution of closely spaced peaks, and in its sensitivity to that obtainable with any continuous flow system. (auth)

**19673** RADIOMETRY AND CRYSTALLIZATION HISTORY OF THE BUCHANAN GRANITE MASSIF, TEXAS, USA. Cook, Beverly Gatlin; Rogers, John J. W. (Rice Univ., Houston, Tex.). Lithos, 1: 398-407(Oct. 1968).

Thorium, U, and K concentrations were determined for 20 samples of the massif by γ spectrometry. The averages and ranges of the elemental concentrations and Th/U and K/Th ratios are tabulated. The major features of the concentrations of these radioactive constituents are discussed. The concentrations of Th and U increased toward the interior. The Th/U ratios were generally greater than 5 ppM. Such ratios were extremely high for normal, unaltered granites. Radiometric data show a decrease of radioactive constituents with increasing differentiation. These abnormal concentrations and trends indicate substantial secondary redistribution of Th and U, and probably other elements, after primary crystallization. Trends of modal composition indicate an increase in acidity toward the margins. The reverse zonation is explained by an equilibrium (equal fugacity) distribution of water in the intruded magma shortly after emplacement. The higher water content of the cooler, outer zones depressed the crystallization temperature of the magma below the actual temperature in the outer regions, thus allowing the interior to crystallize first. Progressive crystallization outward further increased the water content of the margins, and pegmatitic segregations attest to the saturation of the melt in the outer regions. The high water content maintained crystallization in the 2-phase, subsolidus feldspar region throughout most of the pluton. (BBB)

## *Activation Procedures*

*Refer also to abstracts 19979 and 21609.*

**19674** ADSORPTION PHENOMENA IN THE DETERMINATION OF TRACE IMPURITIES OF GERMANIUM AND SILICON BY ACTIVATION ANALYSIS. Nagy, L. G.; Giber, J. (Polytechnical Univ., Budapest). Period. Polytech. Chem. Eng., 12: 37-41(1968).

Factors influencing the reproducibility and the accuracy of the determination of the Cu, Au, and Ag content of high purity Ge and Si by activation analysis were studied. The contamination of the surface and consequently the specific surface area and the mode of treatment before activation were found to be one of the most important factors. When purification before activation is undertaken with concentrated acids and purified water, Cu, Au, and Ag, deposited on the surface, can be removed to the extent that surface impurities do not practically influence measuring results, except for samples of relatively great specific surface area. For Ge results of relatively good reproducibility and accuracy are to be expected only in case of a pretreatment and post-treatment with a $HCl-HNO_3$ and with water whose Cu content was reduced previously by contact with Ge. With Si, the etching agent was a $HF-HNO_3$ mixture. (BBB)

**19675** A CASE CONCERNING NEUTRON ACTIVATION ANALYSIS OF GLASS. Coleman, R. F. (United Kingdom Atomic Energy Authority, Aldermaston, Eng.); Weston, N. T. J. Forensic Sci. Soc., 8: 32-3(Jan. 1968).

The use of neutron activation analysis in comparing physical evidence in a British Court is reported. Samples of glass from a suspect's shoe and samples from a broken window in a house that was burglarized were analyzed by neutron activation for 18 elements. Results showed that the glass from the shoe and the glass from the window probably came from the same batch of manufactured glass. (D.H.M.)

**19676** DETERMINATION OF FLUORINE BY PROMPT γ-RADIATION FROM PROTON BOMBARDMENT. PART II. RESULTS. Bewers, J. M.; Flack, F. C. (Univ. of Exeter, Eng.). Analyst, 94: 7-14(Jan. 1969).

The practical application of the nuclear reaction $^{19}F(p,\alpha\gamma)^{16}O$ to the determination of fluorine is outlined. Analysis in liquid and gaseous phases suffers from the need to use a proton transmission foil. In principle, solids can be analyzed inside the accelerator vacuum, but it is shown that powder targets can be handled more easily by using a foil. Lack of independent standards has prevented absolute calibrations, but it has been demonstrated that fluorine in gases can be determined at relatively high levels (5 to 100%) by a simple system that could easily be adapted, by the use of thicker foils and higher bombarding energies, to reach much lower levels. Determinations in liquids were carried out in the range 20 ppM to 10% of fluorine in aqueous solutions. There is no obvious reason to rule out acidic and alkaline solutions that do not attack the proton window or its holder. Pellet targets were tried for analysis in solids, but it was found that such targets, made by mixing fluorine salts with iron powder, are usually inhomogeneous. Thus, without independent solid standards the method appears to present difficulties, especially in view of the "thin target" behavior of the pelleted samples. Bombardment of the powders, through a foil window was found to be a practical alternative, and it was demonstrated in a selection of ground rock samples that fluorine was distributed homogeneously throughout a given sample. The importance of the stopping power, and hence a knowledge of the molecular form in which the fluorine occurs, has been emphasized for solids; the situation is far less critical for solutions, and for very weak solutions it has been demonstrated that chemical form is immaterial. Interferences are not important, except for aluminium and possibly lithium. The theoretical limits of detection are in good agreement with those observed in practice, being about 20 ppM for the particular background and experimental arrangement used. (auth) (UK)

**19677** DETERMINATION OF FLUORINE BY PROMPT γ-RADIATION FROM PROTON BOMBARDMENT. PART I. THEORY AND EXPERIMENTAL METHOD. Bewers, J. M.; Flack, F. C. (Univ. of Exeter, Eng.). Analyst, 94: 1-6(Jan. 1969).

An analysis is given of factors that are important for quantitative determination of fluorine by means of proton bombardment. The reaction involved is $^{19}F(p,\alpha\gamma)^{16}O$. An expression played by the stopping cross-section is pointed out. The experimental arrangements are discussed. (auth)

**19678** RADIOCHEMICAL MICRODETERMINATION OF MANGANESE, STRONTIUM, AND BARIUM BY ION-EXCHANGE. Hadzistelios, Isidore; Papadopoulou, Catherine (Democritos Nuclear Research Centre, Athens). Talanta, 16: 337-44(Mar. 1969).

A rapid radiochemical ion exchange method was developed for the quantitative separation of microamounts of Mn, Sr, and Ba in the presence of other elements with atomic numbers below 84. The method proposed, combined with neutron activation analysis, was successfully applied to the simultaneous determination of Mn, Sr, and Ba in plant and animal tissues. The method is simple and accurate. (auth) (UK)

**19679** NEW ASPECTS OF CHEMICAL SEPARATION IN NEUTRON ACTIVATION ANALYSIS. Csajka, Maria; Csath, Gabor; Molnar, Ferenc; Oerdoegh, Maria; Rausch, Henrik; Szabo, Elek. KFKI (Kozp. Fiz. Kut. Intez.) Kozlem., 16: 369-80(1968). (In Hungarian).

Chemical separation methods used in activation analysis of rare earths, uranium oxide, some chemical agents, nickel, gallium, and arsenic as well as the compounds of the latter two, are described. For the separation of contaminants from the matrix and from one another, depending on the element to be determined, ion exchange, isotopic exchange, paper chromatography, and group extraction are used. (auth)

**19680** PRECISION DETERMINATION OF GADOLINIUM IN CADMIUM FLUORIDE BY NEUTRON ACTIVATION ANALYSIS. Marsh, R. H.; Allie, W. (Ford Motor Co., Dearborn, Mich.). Anal. Chim. Acta, 45: 179-82(Mar. 1969).

In order to circumvent the difficulties of neutron shielding and yield determinations in the neutron activation analysis of calcium fluoride for gadolinium, a method was employed involving the separation of cadmium before irradiation combined with an internal standard technique. A post-irradiation separation was also used to remove sodium and the last traces of cadmium. The last separation can be eliminated if the spectra due to pure cadmium and sodium is substracted from the gadolinium and samarium spectra. The basic technique is thought to be applicable to the determination of most rare earths in cadmium fluoride, and perhaps also to many other trace constituents in cadmium fluoride which form insoluble hydroxides in ammoniacal solutions and which do not form cyanide complexes. (D.H.M.)

**19681** INVESTIGATION OF A RAPID AND NON-DESTRUCTIVE FAST-NEUTRON ACTIVATION ANALYSIS FOR MANY ELEMENTS BY USING A SEMI-CONDUCTOR DETECTOR. Fujii, I. (Tokyo Shibaura Electric Co. Ltd., Kawasaki, Japan); Inouye, T.; Muto, H.; Onodera, K; Tani, A. Analyst, 94: 189-97(Mar. 1969).

Investigations in the field of fast-neutron activation analysis with a small neutron generator have established that oxygen in various materials can be determined by this rapid, non-

destructive method. The study described was carried out to investigate the applicability of the method with a germanium (lithium) γ-ray detector and data processing by electronic computer, for many other elements. More than sixty elements were activated under the following conditions: bombarding time 400 seconds; neutron output $5 \times 10^{10}$ neutrons second$^{-1}$; counting time 500 seconds after cooling; cooling time 10 seconds after bombardment; and sensitivities under these conditions were calculated. It was found that many elements, in addition to oxygen, can be determined by this method without chemical separation. (auth) (UK)

**19682** APPLICATION OF A FAST NEUTRON ACTIVATION METHOD TO THE CONTROL OF OXYGEN CONTENT IN IRON AND STEEL MAKING PROCESS. Miyagawa, Kazuo; Shimura, Kazuteru (Fuji Iron and Steel Co., Ltd., Japan). Tetsu To Hagane, 55: 209-15(Feb. 1969). (In Japanese).

A rapid, nondestructive neutron activation method was investigated for determination of O in steel. The oxide film formed on the surface of the sample must be ground off before shaping. For values of O between 0.1 and 0.001%, the results by this method were in good agreement with those by vacuum fusion method. The standard deviation of the method is ±7%. (NSA of Japan)

**19683** ACTIVATION ANALYSIS OF TRACE ELEMENTS IN REFINED SOYBEAN OILS. 3. DETERMINATION OF GOLD. Shinbori, Yoshio; Tamachi, Toshio. Radioisotopes (Tokyo), 18: 26-9(Jan. 1969). (In Japanese).

After neutron activation, the radioactive Au is prepared for determination by ashing the sample in a muffle furnace, dissolving the ash in a mineral acid, and preparing solid samples by reduction. The activity of Au is measured by $\beta-\gamma$ coincidence and γ counting. The detection limit is $10^{-8}$ g for Au for samples of 2 to 3 g irradiated with a neutron flux of $\sim 10^{11}$ n/cm$^2$·sec for a maximum of 30 hr. (NSA of Japan)

**19684** DETERMINATION OF MOLYBDENUM IN SOIL EXTRACTS BY NEUTRON ACTIVATION ANALYSIS. Zmijewska, Wanda; Minczewski, Jerzy (Inst. of Nuclear Research, Warsaw). Chem. Anal. (Warsaw), 14: 23-7(1969).

A neutron activation method for the determination of molybdenum in soil extracts is described. The method is based upon gamma spectrometric measurement of the 141-keV photopeak activity of $^{99}$Mo and its daughter $^{99m}$Tc after radiochemical separation of molybdenum by extraction with diethyl ether from 6 N HCl followed by extraction with a chloroform solution of α-benzoinoxime. The lower limit of determination amounts to 1 ng Mo. The standard deviation as calculated from a series of 18 measurements did not exceed 8% for molybdenum content of the order of 10 ng and increased up to 26% for the content of 1 ng (6 measurements). (auth)

**19685** DETERMINATION OF ALUMINIUM IN A NIMONIC ALLOY BY ACTIVATION WITH FAST NEUTRONS. Quigley, D. A. (Royal Arsenal, London); Trussler, J. W. A. Talanta, 16: 438-43(Mar. 1969).

Aluminium at the 6% level was determined in a 15-component "nimonic" alloy with a coefficient of variation of ±8.7% by using fast-neutron activation followed by pulse-height analysis of gamma spectra. The possibility of determining chromium, iron, cobalt, and manganese is also discussed. (auth) (UK)

**19686** RADIOCHEMICAL IMPURITIES IN THE PROCESSED $^{56}$Mn BY (n, γ) REACTION. Nakamura, Haruto; Yamabayashi, Hisamichi (Japan Atomic Energy Research Inst., Tokyo). Nippon Genshiryoku Gakkaishi, 11: 134-7(1969). (In Japanese).

Electrolytically purified manganese metal was used as target material for the production of $^{56}$Mn by (n, γ) reaction. The impurities were first roughly determined by nondestructively measuring their radioactivities after irradiation, and then precisely by combining chemical separation with activation analysis. Antimony, chromium, scandium, and europium were found present, to the extent of a few ppM or lower. In addition, $^{54}$Mn produced by $^{55}$Mn(n,2n)$^{54}$Mn reaction with fast neutrons was also detected. In order to estimate the production rate of this $^{54}$Mn, the activation, cross section of this nuclear reaction was estimated from the activities of $^{54}$Mn in a manganese target irradiated in one of the hollow fuel elements of JRR-2. It was estimated to be 0.19 mb which roughly agreed with the previously reported value of 0.16 mb. Radiochemical impurities in the $^{56}$Mn produced in the Japan Atomic Energy Research Institute were estimated from the values obtained above and the irradiation conditions used for the production. It was found that the product is 99.999% radiochemically pure $^{56}$Mn. (auth)

**19687** PRODUCTION OF RADIOACTIVE COLLOIDAL GOLD $^{198}$Au AT THE BORIS KIDRIC INSTITUTE OF NUCLEAR SCIENCES, VINCA, YUGOSLAVIA. PART III. DETERMINATION OF THE RADIOACTIVE PURITY OF RADIOACTIVE GOLD $^{198}$Au AND THE RADIOACTIVITY RATIO OF $^{198}$Au/$^{199}$Au AS A FUNCTION OF NEUTRON FLUXES. Draskovic, R. J.; Draskovic, R. S. (Boris Kidric Inst. of Nuclear Sciences, Vinca, Yugoslavia). Isotopenpraxis, 5: 11-13(Jan. 1969). (In French).

The radioactive purity of radiocolloidal gold and the activity ratio of $^{198}$Au/$^{199}$Au for $E_\gamma$ = 0.420 MeV and $E_\gamma$ = 0.170 MeV, as a function of neutron fluxes, were determined by the method of activation analysis. Radiocolloidal gold $^{198}$Au produced at the Boris Kidric Institute of Nuclear Sciences at Vinča, used in medicine (YV $^{198}$Au/1, 4 and 5, for therapeutic, diagnostic, and lymphographic purposes) was investigated. The radioactivity ratio of $^{198}$Au/$^{199}$Au was determined as a function of the neutron fluxes used for the irradiation of Au foils in the RA reactor. This ratio decreases with increasing fluxes. (auth)

# Inorganic, Organic, and Physical Chemistry

*Refer also to abstracts 19768, 19817, 19843, 20041, 20981, 20999, and 21004.*

**19688** (ANL-7463) REDUCTION OF URANIUM DIOXIDE IN MOLTEN SALT-METAL SYSTEMS. Wenz, D. A.; Wolson, R. D.; Johnson, I. (Argonne National Lab., Ill.). Nov. 1968. Contract W-31-109-eng-38. 13p. Dep. CFSTI.

A study was made of the reducibility of sintered $UO_2$ powder and pellets in agitated, immiscible molten salt-metal alloy systems. Systems consisting of a salt mixture having less than about 25 mol % $MgCl_2$ and the alloy Mg-44 at. % Cu proved to be unsatisfactory media for $UO_2$ reductions. The use of salts containing about 50 mol % $MgCl_2$ with the above alloy allowed good reductions of $UO_2$ powder, but reductions of larger particles of $UO_2$ were too slow for process purposes. These results suggest an inhibition of reduction by the insoluble MgO reduction product. Utilization of a $CaCl_2$ salt/Cu-Mg-Ca alloy reduction system, where the CaO reduction product dissolves in the salt phase, gave rapid, complete reduction of even $UO_2$ pellets. The experimental data suggest that $UO_2$ reduction proceeds through reaction of $UO_2$ at the solid-particle surface with magnesium or calcium metal dissolved in the salt phase (as the species $Mg_2^{2+}$ or $Ca_2^{2+}$). (auth)

**19689** (ANL-Trans-738) THERMODYNAMIC STABILITY OF $UF_6$. Tumanov, Yu. N. Translated by Elmar K. Wilip (Argonne National Lab., Ill.), from Zh. Neorg. Khim., 13: 1488-93 (1968). 12p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 22: 37763.

**19690** (ARH-147) PROPERTIES OF POTENTIAL URANIUM PRECIPITATES AS RELATED TO CHEMICAL PROCESSING. Colvin, C. A. (Atlantic Richfield Hanford Co., Richland, Wash.). Oct. 30, 1967. 10p. Dep. CFSTI.

Density and uranium contents of settled precipitates must be known to calculate uranium safety parameters. Studies on precipitates of sodium polyuranates, behavior of plutonium when sodium polyuranate is precipitated, methods of precipitating sodium polyuranates, precipitation of uranyl ion by sodium carbonate, and precipitates of other uranium compounds are described. (M.C.G.)

**19691** (CONF-680610-, pp 2-17) CHEMISTRY OF PLUTONIUM HEXAFLUORIDE. Steindler, Martin J. (Argonne National Lab., Ill.).

A brief review is given on the preparation and properties of $PuF_6$. The properties discussed include: stability, compatibility, activation energy, crystallization, thermodynamics, chemical reactions, equilibrium at various temperatures, thermal decomposition, and safety aspects. (P.C.H.)

**19692** (EUR-4096) INFLUENCE OF GRAPHITE ON FOULING. Hoepper, M.; Diletti, F.; Van Rutten, F. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1968. 24p. (In French). Dep.

A study of the reaction between $FeCl_3$ and terphenyl allowed a possible explanation of fouling in the presence of chlorine. Graphite acts as a catalyst for the fouling reaction on its own surface and consequently decreases the deposition on hotter parts of organic circuits. (auth)

**19693** (ORNL-4344, pp 109-99) CHEMISTRY. Grimes, W. R. (Oak Ridge National Lab., Tenn.).

Topics covered include: chemistry of the MSRE, fission product

behavior, physical chemistry of molten salts, chemistry of molten-salt reactor fuel reprocessing technology, and development and evaluation of analytical methods for molten-salt reactors. (M.C.G.)

**19694** (SC-R-68-1680) FUSED SALT MIXTURES: EUTECTIC COMPOSITIONS AND MELTING POINTS. Bibliography, 1907–1968). Clark, Paul V.; Dean, Crowell O. (Sandia Labs., Albuquerque, N. Mex.). Dec. 30, 1968. 794p. Dep. CFSTI. Supersedes SC-R-65-930(Vols. 1 and 2).

Data on eutectic compositions and melting points of fused salt mixtures are presented in two complementary tables arranged by systems and by melting points. Over 5,000 references are given through December 30, 1968. (auth)

**19695** (UCRL-Trans-10328) HYDROLYSIS OF THORIUM CHLORIDE. Chauvenet, E.; Tonnet, J. Translated by Z. F. St-Gallay for Univ. of California, Lawrence Radiation Lab., Livermore, from Bull. Soc. Chim. Fr., (4) Serie, 47-8, No. 7, 701-3(1930). 6p. Dep. CFSTI.

Reactions of anhydrous thorium chloride with water were studied. When a NaOH solution was introduced, the HCl produced in the reactions was neutralized and thorium precipitated in the form of $Th(OH)_4$. The neutralization was monitored by measuring the electric conductivity. The resistance was plotted against the volume of NaOH used and this gave two straight lines intersecting at a point corresponding to 10 ml of NaOH. It was therefore concluded that the reaction proceeds: $ThCl_4 + 2H_2O \rightleftharpoons ThCl_2(OH)_2 + 2HCl$. Results indicated the presence of a thoryl radical (ThO) in dilute solutions of $ThCl_4$. (M.C.G.)

**19696** ELECTROLYTIC REDUCTION OF $K_2NbF_7$ IN AN NaCl–KCl EUTECTIC BATH. Sakawa, Mitsuhiro; Kuroda, Tadashi (Tokyo Inst. of Tech.). Denki Kagaku, 37: 99-103(Feb. 1969). (In Japanese).

The mechanism for the electrodeposition of niobium was studied by means of chronopotentiometry and controlled-current coulometry. The reduction of $K_2NbF_7$ in an NaCl–KCl eutectic bath occurred in two steps: first a reversible two electron step, and then an irreversible process. The first step was a diffusion controlled. The diffusion coefficient was founded to be $4.9 \times 10^{-5}$ cm²/sec at 750°C, and its activation energy for diffusion to be 9.2 kcal/mol. The low value of the diffusion coefficient and the high activation energy was probably consistent in a highly complex reducible species. The second step was not diffusion controlled and only poorly understood. (NSA of Japan)

**19697** THE SYNTHETIC ELEMENTS. IV. Seaborg, Glenn T.; Bloom, Justin L. (Atomic Energy Commission, Washington, D. C.). Sci. Amer., 220: No. 4, 57-67(Apr. 1969).

Recent work on the synthesis of superheavy elements gives rise to the prospect that the list of the elements can be extended far beyond what had been thought possible. Experimental results concerning elements 101 and 105 are reported, and the theories of nuclear structure that have led to optimism about identifying elements far beyond the region of atomic number 100 are reviewed. Chemical properties and applications of the superheavy elements are also discussed. (D.H.M.)

**19698** ISOTOPE EFFECT AND HYDROGEN BONDING IN CRYSTALLINE HYDRAZINIUM HYDROGEN OXALATE, $N_2H_5HC_2O_4$. Lindgren, J.; De Villepin, J.; Novak, A. (Faculte des Sciences, Paris). Chem. Phys. Lett., 3: 84-6(Feb. 1969).

Infrared spectra of hydrazinium hydrogen oxalate, $N_2H_5HC_2O_4$, and of its deuterated derivative, $N_2D_5DC_2O_4$, were studied at liquid nitrogen temperature in the 3600 to 200 $cm^{-1}$ range. It appears that the symmetric O..H..O hydrogen bond of the hydrogen oxalate chains becomes asymmetric when hydrogen is substituted by deuterium. (auth)

**19699** KINETICS OF THE DISSOLUTION OF URANIUM DIOXIDE IN NITRIC ACID. II. Shabbir, Muhammed; Robins, R. G. (Univ. of New South Wales, Kensington, Australia). J. Appl. Chem., (London), 19: 52-6(Feb. 1969).

The kinetics of the dissolution of uranium dioxide in nitric acid were investigated at temperatures up to 150°C and oxygen and argon gas pressures up to 1150 psig. A mechanism for the high-pressure process is proposed which is consistent with experimental reaction rates and the mechanism proposed previously for temperatures below 100°C. (auth) (UK)

**19700** METHYL AND TRIFLUOROMETHYL RADICAL ATTACK ON METHYL FORMATE: ISOTOPE EFFECTS AND REACTIVITIES AT DIFFERENT SITES. Arthur, N. L.; Gray, Peter (Univ. of Leeds, Eng.). Trans. Faraday Soc., 65: 424-33(Feb. 1969).

Isotopic labelling was employed to determine the position and extent of hydrogen abstraction from the formyl and methoxyl sites in methyl formate by methyl and trifluoromethyl radicals. Attack is principally at the formyl group, but at 182°C a significant proportion of abstraction occurs from the methoxyl (15% for attack by $CH_3$ and 25% for attack by $CF_3$). Values for rate constants (at 182°C) and for Arrhenius parameters are given. Isotope effects at the formyl group are similar for both methyl and trifluoromethyl abstractions. At 182°C the velocity constant for H-abstraction is 6.2 times that for D-abstraction when attack is by methyl radicals; the isotopic factor is 8 when attack is by trifluoromethyl radicals. These effects are due to activation energy differences, since quotients of A-factors do not differ from unity. Zero-point-energy differences, however, are less by ca. 0.5 kcal $mole^{-1}$ than the differences in activation energy, and proton tunnelling may be important. (auth) (UK)

**19701** ISOTOPE EFFECTS IN REACTIONS OF TRIFLUOROMETHYL RADICALS WITH HYDROGEN CHLORIDE AND HYDROGEN SULPHIDE. Arthur, N. L.; Gray, Peter (Univ. of Leeds, Eng.). Trans. Faraday Soc., 65: 434-40(Feb. 1969).

Rate constants, Arrhenius parameters, and primary kinetic isotope effects were measured for the reactions of trifluoromethyl radicals with $H_2S$, $D_2S$, HCl and DCl. Quotients of A-factors do not differ significantly from unity, but values for $(E_D - E_H)$ are significantly less than the respective zero-point-energy differences $\Delta E_0$ of 1.1 kcal $mole^{-1}$. The reactivity of $CF_3$ radicals towards the two substances is markedly less than that of $CH_3$ radicals; the differences reside in the higher activation energies and may be attributed to the polar character of $CF_3$. (auth) (UK)

**19702** REDUCTION OF $U_4O_9$ BY HYDROGEN IN THE PRESENCE OF ADDITIONS OF MgO. Vlasov, B. G.; Pis'menko, V. T.; Larin, A. A. (Ural Polytechnic Inst., Sverdlovsk, USSR). Kinet. Katal., 9: 1094-1100(Sept.-Oct. 1968). (In Russian).

The influence of homogeneous and heterogeneous additions of MgO on the reduction of $U_4O_9$ by hydrogen was studied. In the case of homogeneous additions, a complex relation to rate of reduction was observed. In the case of heterogeneous additions, an increase in the rate of reduction occurred. The influence of homogeneous additions of MgO on crystal structure and electric conductivity was studied. The influence of additions of MgO on the reduction process is related to the quantity and type of defects generated in the reduced oxide. (tr-auth)

**19703** PREPARATION OF CURIUM METAL. Eubanks, I. D.; Thompson, M. C. (E. I. du Pont de Nemours and Co., Aiken, S. C.). Inorg. Nucl. Chem. Lett., 5: 187-91(Mar. 1969).

Several grams of Cm metal were prepared, with a view to determining its physical and chemical properties, by reduction of the oxide with Mg in molten Mg–Zn alloy. The oxide was suspended in a molten flux that included $MgCl_2$, the actinide metal being extracted into the molten alloy, and subsequently recovered by vacuum distilling off the Mg and Zn. The distribution coefficient for Cm into the $MgCl_2$ was found to be a minimum ($< 2 \times 10^{-2}$) when the Mg concentration was 10 wt % in the alloy, and this alloy composition was chosen for the preparation. $MgF_2$ was added to the flux to decrease the solubility of the alloy in the flux and thus give a cleaner interface. The temperature employed was 800 to 900°C, using a tungsten crucible with argon atmosphere, and the reaction time was 1½ to 2 hours. The product was poured into a BeO casting crucible and cooled in the inert gas atmosphere. The Mg–Zn–Cm alloy was recovered by dissolving the flux with distilled water. Yields were 75 to 90%. The largest single piece of metal obtained weighed 1.25g. Spectroscopic analysis data are given; the melting point was found to be 1350 ± 60°C. Some data are given on physical properties. The method is stated to minimize neutron exposure to personnel, since the Cm is never mixed homogeneously with any element with large $(\alpha,n)$ cross section; it is also well suited to remote handling. (UK)

**19704** ISOTOPIC EFFECTS IN THE COURSE OF FRAGMENTATION OF ACETYLENE IN A MASS SPECTROMETER. Guyon, Paul-Marie; Fiquet-Fayard, Florence (CNRS, Orsay, France). J. Chim. Phys., 66: 32-4(Jan. 1969). (In French).

$C_2H^+$, $CH^+$, $C_2^+$, $C^+$, $C_2H_2^+$, and their deuterated derivatives were studied in $C_2H_2$, $C_2HD$, and $C_2D_2$. In $C_2HD$ breaking of the CH bond was 1.9 times as probable as breaking of the CD bond. This effect is in agreement with the assumption of a predissociation. Many other isotopic effects are reported; for some of them tentative explanation is suggested. (auth)

**19705** PREDISSOCIATIONS IN THE DISSOCIATIVE IONIZATION OF FORMALDEHYDE. I. STUDY OF ISOTOPIC EFFECTS ON THE DISSOCIATION OF $H_2CO$, HDCO, AND $D_2CO$ BY ELECTRON IMPACT. Guyon, Paul-Marie; Tronc, Michel (CNRS, Orsay, France). J. Chim. Phys., 66: 35-40(Jan. 1969). (In French).

The mass spectra of formaldehyde ($H_2CO$, HDCO, $D_2CO$) were compared in order to measure the isotope effects occurring in the dissociation. The formation process of $XCO^+$ (X = H or D) shows mainly two effects. The first one is caused by the different behaviour of the three molecules. At 70 eV the abundances of $XCO^+$ were found to be $A_{HDCO}/A_{D_2CO} = 1.42$ $A_{H_2CO}/A_{D_2CO} = 1.35$. The second one is caused by competition between the rupture of the CH and the CD bonds in HDCO molecule. The probability of CH bond rupture at 70 eV is 3.3 times that of the CD bond. In the $D_2CO$ spectrum a peak at the apparent mass of 28.13 was found, arising from the metastable transition $D_2CO^+ \rightarrow DCO^+ + D$. (auth)

**19706** CHEMICAL BEHAVIOR OF THE TRANSPLUTONIUM ELEMENTS IN AQUEOUS SOLUTION. Eberle, S. H. (Univ., Karlsruhe, Ger. Kernforschungszentrum, Karlsruhe, Ger.). Atompraxis, 15: 18-21(Jan.-Feb. 1969). (In German).

A survey was made of the chemical behavior and the complex formation equilibria of the transplutonium elements in aqueous solution. The elements Th to Lw form the homologous chain of the actinides because of the structure of their electron shells ($7s^2\ 6d^1\ 5f^n$), in analogy with the lanthanides. The elements 104 (Kurchatovium) and 105 probably belong to the fourth and fifth subgroup, respectively. As members of a homologous chain the transplutonium actinides are chemically very similar at equal ionization stages. Their main valency is 3+; in addition, there exist bi-, tetra-, penta-, and hexavalent ions in some cases. (auth)

**19707** SOLID CHEMISTRY OF THE TRANSURANIUM ELEMENTS. Keller, C. (Univ., Karlsruhe, Ger. Kernforschungszentrum, Karlsruhe, Ger.). Atompraxis, 15: 21-5(Jan.-Feb. 1969). (In German).

In comparison with rare earth oxides the binary oxides of transuranium elements show a remarkable coincidence in their reactivity and structure, because only oxides and oxide phases between $MeO_{1.50}$ and $MeO_2$ are thermally stable. Only oxide hydrates are known of the higher valency states. By splitting off water they transform into the corresponding dioxide at low temperatures either directly or via very unstable intermediate products. Ternary oxides and oxide phases no longer show this close relationship to the lanthanides. The surprisingly high thermal stability of the pentavalent and hexavalent compounds of neptunium, plutonium, and americium as well as their lattice structures therefore can be compared better with the properties of analogous uranium and protactinium compounds. By a solid reaction of $NpO_2$ with $Li_2O$ at 410°C the first pure compound of heptavalent neptunium could be obtained in form of $Li_5NpO_6$, which can be unequivocally defined by crystallography. (auth)

**19708** THE RADIATION CHEMISTRY OF ALCOHOLS. VII. METHANE FORMATION IN THE U/V PHOTOLYSIS OF NEUTRON-ISOPROPANOLS. von Sonntag, C. (Kernforschungszentrum, Karlsruhe, Ger.). Int. J. Radiat. Phys. Chem., 1: 33-7(Jan. 1969). (In German).

The photolysis of several deuterated isopropanols was studied with light of wavelength $\lambda = 185$ nm. The isotopic composition of the methane formed was measured. In contrast to the $\gamma$ radiolysis of isopropanol where methyl radicals are the precursors of 95 percent of the methane formed, methyl radicals yield only ca. 8 percent of the methane in the uv photolysis. The major part is formed in a molecular fragmentation process; 66 percent by a simultaneous elimination of a methyl group and the OH-hydrogen and 26 percent by the elimination of one methyl group and a hydrogen of the other methyl group. In the first case acetaldehyde and in the second case the enol-form of acetaldehyde are the other products. (auth)

**19709** COMPARISON OF ELECTRIC POTENTIALS OF THE Bk(IV)–Bk(III), AND Ce(IV)–Ce(III) COUPLES. Weaver, B.; Fardy, J. J. (Oak Ridge National Lab., Tenn.). Inorg. Nucl. Chem. Lett., 5: 145-6(Mar. 1969).

The difference in formal potentials at 25°C in $HNO_3$ solution was measured by determination of the relative concentrations of the oxidized and reduced species of Bk and Ce in equilibrium in aqueous solution. Application of the Nernst equation gave the potential in volts. The concentration ratios of Ce(IV) and Ce(III) were fixed experimentally by mixing solutions of $(NH_4)_2Ce(NO_3)_6$ and $Ce(NO_3)_3$ and were not significantly altered by addition of tracer $^{249}Bk$. The equilibrium concentration ratios of Bk(IV) and Bk(III) were determined by extraction of the Bk(IV), together with the Ce(IV), without significant extraction of Bk(III) or Ce(III), into di(2-ethylhexyl) phosphoric acid, followed by measurement of the relative concentrations of $^{249}Bk$ in the two phases. Extractions were performed within a few minutes of making up the aqueous solutions in order to minimize extraneous reduction of the cerium. In all experiments Ce(IV) was found to be a stronger oxidizing agent than Bk(IV). The potential of the cerium couple was found to be approximately 0.06 V higher than that of the Bk couple in 1 to 4N $HNO_3$. (UK)

**19710** PREPARATION OF $^{238}Pu^{16}O_2$ BY OXYGEN EXCHANGE WITH $H_2$ $^{16}O$. Porter, J. A.; Thompson, M. C. (E. I. du Pont de Nemours and Co., Aiken, S. C.). Inorg. Nucl. Chem. Lett., 5: 129-34(Mar. 1969).

A process is reported for the preparation of $^{238}Pu^{16}O_2$ by oxygen exchange between the oxide and water vapor depleted in $^{17}O$ and $^{18}O$. It is pointed out that $^{238}Pu^{16}O_2$ has a substantially lower neutron emission rate than oxide with natural oxygen isotopic composition due to the absence of $(\alpha,n)$ reactions with $^{17}O$ and $^{18}O$; this is very desirable in applications of $^{238}PuO_2$ isotopic power sources. $^{238}PuO_2$ powders containing oxygen isotopes in natural abundance were prepared from the oxalate, and water depleted to 0.01% in both $^{17}O$ and $^{18}O$ was purchased. In batch equilibration studies the $PuO_2$ was contained in a Pt boat located in the heated zone (700°C) of an evacuated quartz tube, and the water vapor at a pressure of 30 to 40 min. was continually distilled backwards and forwards through the tube. All samples were protected from atmospheric contamination. The efficient production of the required $^{238}PuO_2$ was demonstrated in a column reactor. Oxygen isotopic composition was determined mass spectrometrically, and the neutron emission rate was measured with a $BF_3$ counter. The most highly depleted $^{238}PuO_2$ produced contained 0.017% $^{18}O$. Neutron emission rates are shown plotted against percent $^{18}O$ content. Tests were also made with $^{239}PuO_2$ microspheres prepared by the sol-gel process. (UK)

**19711** OXIDATION OF $Cf^{3+}$ IN AQUEOUS SOLUTIONS. Propst, R. L.; Hyder, M. L. (E. I. du Pont de Nemours and Co., Aiken, S. C.). Nature (London), 221: 1141-2(Mar. 22, 1969).

A conducting glass electrode was used in conjunction with scanning coulometry to study the redox processes in solutions of Cf. The electrode was prepared by deposition of an Sb-doped tin oxide surface on borosilicate glass. Very fast scanning was provided in the reduction direction in the region of $O_2$ evolution. Rapid anodic scanning was necessary since the oxidized species rapidly disappeared, with a lifetime of ~2 min. A reduction coulogram recorded immediately after electrolysis of a solution of $^{249}Cf$ in 0.25M $H_2SO_4$ is illustrated. A wave at +0.95 V was observed, which was characteristic of the Cf solution. Electrolysis for longer periods did not produce increased amounts of the species responsible for this wave, the height of which depended on the rate of the reduction scan. For slower scan rates this wave was not observed, indicating that the responsible species was highly unstable and decomposed rapidly with time. This characteristic reduction wave was also observed in solutions buffered with bicarbonate, the characteristic potential being shifted to +0.8 V at pH 4, and the wave height being slightly increased, suggesting increased stability for the Cf species. Assignment of the higher oxidation state is somewhat speculative; Cf(IV) was discounted. (UK)

**19712** SECONDARY DEUTERIUM ISOTOPE EFFECTS IN TRIFLUOROACETOLYSIS OF ISOPROPYL p-TOLUENESULFONATE. Streitwieser, A.; Dafforn, G. A. (Univ. of California, Berkeley). Tetrahedron Lett., No. 16, 1263-6(Mar. 1969).

It was thought that a study of deuterium isotope effects in solvolysis of a secondary tosylate would provide useful evidence concerning the nucleophilicity of trifluoroacetic acid and the relative limiting character of "ordinary" solvolyses of secondary sulfonate esters. The rates of trifluoroacetolysis of isopropyl-$\alpha$-d and isopropyl-$\beta$-$d_6$ p-toluenesulfonates are reported. The rates were measured using the uv method of Peterson et al. (J. Amer. Chem. Soc., 87: 5169(1965)). The rate for the undeuterated compound was also measured. The calculated isotope effects were $(k_H/k_D)_\alpha = 1.22 \pm 0.02$ and $(k_H/k_D)_\beta = 2.12 \pm 0.1$. (UK)

**19713** VIBRONIC ANALYSIS OF THE ABSORPTION SPECTRUM OF THE URANYL ION. De Jaegere, S.; Goerller-Walrand, C. (Univ. of Louvain, Belgium). Spectrochim. Acta, Part A, 25: 559-68(Mar. 1969).

A calculation of the potential energy curves for the first three excited states of the uranyl ion is proposed. Because of the lack of clearly defined progressions in the absorption spectrum, experimental values of the dissociation energy are introduced into the calculations. These values are obtained from the positions of the distinct continua, observed by Pringsheim in the ultraviolet part of the absorption spectrum. This enables calculation of theoretical progressions, which are found to be in good agreement

with the poorly defined experimental progressions. The vibronic analysis proposed allows also for a quite reasonable interpretation of the intensity distribution in the absorption spectrum of the uranyl ion. (auth) (UK)

**19714** GASEOUS PHASE REACTIONS OF CARBON IN URANIUM VACUUM MELTING. Umemura, Teruyoshi; Tejima, Tatuo (Saitama Univ., Japan). Sci. Eng. Rep., Saitama Univ., Ser. C, No. 1, 1-12(May 1967). (In Japanese).

Experiments were initiated to control carbon pick-up in vacuum melting of uranium. The most important reactions were regarded to be the following: C(in U) $+ \frac{1}{2} O_2 = CO$, $C + O_2 = CO_2$, and $C + CO_2 = 2CO$. These reactions are discussed thermodynamically and kinetically in considerable detail. It was known that both carburization and decarburization would take place in significant amounts at higher pressures than $3 \times 10^{-4}$ to $1 \times 10^{-5}$ torr. Using five different types of furnaces, the following observations were made: (1) the reactions depend greatly on the furnace structure such as existence of heated graphite, refractories, their sizes and installations, (2) the gases on the molten uranium tend, however, to have the equilibrium composition of 100 to 800 ppM dissolved carbon. It was concluded that the decarburizing reaction is $C + CO_2 = 2CO$. (NSA of Japan)

**19715** METHOD FOR PRODUCING A BENZYL CHLORIDE DERIVATIVE WITH RADIATION. Abe, Toshihiko (to Japan Atomic Energy Research Inst.). Japanese Patent 1968-27212. Nov. 22, 1968. Filed Nov. 4, 1967.

An aromatic hydrocarbon having at least one alkyl or cycloalkyl group, and carbon tetrachloride are mixed together. The mixture is irradiated with a high-energy ionizing radiation to obtain a benzyl chloride derivative, together with chloroform as a by-product. (NSA of Japan)

**19716** NMR OF WATER OF CRYSTALLIZATION IN AUTUNITES. Sugitani, Yoshinori; Fujiwara, Shizuo (Tokyo Univ.). Nippon Kagaku Zasshi, 90: 52-6(Jan. 1969). (In Japanese).

Proton magnetic resonance of single-crystal autunite, $Ca(UO_2)_2(PO_4)_2 \cdot n\ H_2O$, was studied at room temperature, and the directions of the lines connecting two protons in each water molecule are found to be parallel to the c-axis of the crystal. Autunite group minerals containing metal ions other than calcium ion, and those containing arsenate ions in place of phosphate ions were prepared and PMR measurements were made in the temperature range from −150 to +100°C. Spectra at temperatures below about −50°C were broad, corresponding to tightly fixed water molecules in the structure. The narrowing with increasing temperature was observed in the spectra, which had a sharp absorption corresponding to the rapid motion of water molecules. This narrowing occurred at about −10°C in cases of monovalent metal ions and at about 100°C in cases of divalent metal ions. A model is proposed for two dimensional hydration and dehydration mechanisms of metal ions. The second moments calculated from this model are in good agreement with the observed moments. (NSA of Japan)

**19717** PRECIPITATION OF URANYL ION IN FUSED POTASSIUM THIOCYANATE. Yanagi, Tadashi (Osaka Univ.). Bunseki Kagaku, 18: 195-8(Feb. 1969). (In Japanese).

The variations of concentration with time of several metal ions dissolved in fused potassium thiocyanate at 190°C were investigated. It was found that the concentration of cadmium, lead, or neodymium ions did not vary with time in this fused solvent for more than ten hours. In molten salt solutions, uranyl ions separated after a few hours as a black precipitate resulting from chemical reactions with the fused salt. Concentration of uranyl ion therefore decreased with time, while that of the other metal ions remained constant. Chemical analyses of the black precipitate showed that it contained 76.8% uranium and 10.6% sulfur. The contents of the several metal ions in the black precipitate obtained by heating the molten salt solution for a long time at 190°C were: Cd 1.86%, Pb 4.36%, Ce 6.97%, and Nd 8.47%. It is supposed that these were caused by their coprecipitation with uranyl ions. (NSA of Japan)

**19718** DECOMPOSITION OF ORGANOMETALLIC COMPOUNDS TO REFRACTORY CERAMICS, METALS, AND METAL ALLOYS. Proceedings of the 1967 International Symposium, Dayton, Ohio. Mazdiyasni, K. S. Dayton, Ohio, University of Dayton Press, 1968. 346p. (CONF-671139).

Twenty-three papers on organometallic compounds and their use in the production of refractory ceramics and metals are presented. (M.C.G.)

**19719** ADDUCTS OF URANYL CARBOXYLATES. Siddall, T. H. (E. I. du Pont de Nemours and Co., Aiken, S. C.); Stewart, W. E.; McDonald, R. L. Inorg. Nucl. Chem. Lett., 5: 101-4 (Feb. 1969).

Reference is made to the authors' paper in Inorg. Nucl. Chem. Letters, 3: 279(1967) in which a compound $UO_2(CH_3CO_2)_2 \cdot 2[(iso\text{-}C_3H_7O)_2P(O)C_6H_5]$ was reported. It is now reported, from PMR spectra and chemical analysis, that the correct formula of this compound is $UO_2(CH_3CO_2)_2 \cdot (iso\text{-}C_3H_7O)_2P(O)C_6H_5$. Observation of a coordination number of five for the $UO_2$ group in this compound led the authors to synthesize and study a variety of adducts of uranyl carboxylates, and to examine their PMR and near-visible spectra near 4,000Å. Analytical data for seven typical adducts are tabulated; these include compounds of the type $UO_2(RCO_2)_2 \cdot L(A)$, where R = iso-$C_3H_7$, $C_6H_5CH_2$, and $(C_2H_5)_2CH$, and L represents a wide variety of amides and organophosphorus compounds; and also compounds $UO_2(RCO_2)_2 \cdot h(B)$, where h = bipyridyl and several substituted o-phenanthrolines. A dimeric structure is indicated for compounds of type (A) in the solid state, and they may exist as large, possibly polymeric species, in solution. The PMR spectra are discussed in detail. Compounds of type (B) are entirely different from type (A), appearing to exist as hexacoordinate monomers, as compared with pentacoordinate dimers (or high polymers) for type (A). (UK)

**19720** CRYSTALLOGRAPHY OF THE COMPOUNDS OF CALIFORNIUM. II. CRYSTAL STRUCTURE AND LATTICE PARAMETERS OF CALIFORNIUM OXYCHLORIDE AND CALIFORNIUM SESQUIOXIDE. Copeland, J. C.; Cunningham, B. B. (Univ. of California, Berkeley). J. Inorg. Nucl. Chem., 31: 733-40(Mar. 1969).

Californium oxychloride was found to exhibit the tetragonal PbFCl-type structure. X-ray diffraction data from three polycrystalline samples gave the average lattice parameters a = 3.956 ± 0.002 and c = 6.662 ± 0.009 Å, where the error limits represent the 95% confidence interval. Three samples of a low-temperature californium sesquioxide were prepared. Two of these samples, prepared by the hydrolysis of other californium compounds, were found to exhibit the cubic, $Mn_2O_3$-type structure with the average lattice parameter a = 10.838 ± 0.020 Å. The third sample, reacted in oxygen, had the lattice parameter a = 10.809 ± 0.003 Å, where the error limits represent the 95% confidence level and reflect the internal consistency of the data for that particular sample. In an earlier study the lattice parameter of an air-ignited oxide sample was 10.811 ± 0.005 Å; on treatment with $H_2$(g) the lattice parameter increased by 0.49%. These changes in the lattice parameter may reflect small departures from the sesquioxide stoichiometry and thus may constitute evidence for higher and/or lower oxidation states of californium. (auth) (UK)

**19721** ADSORPTION OF URANIUM HEXAFLUORIDE. I. Mueller, L. (Mecsek Ore Mining Enterprise, Pecs, Hungary). Acta Chim. Acad. Sci. Hung., 59: 1-13(1969).

The reversible sorption of uranium hexafluoride as adsorbate was measured on metal and plastics adsorbents. The isotherms characterizing the examined pairs of adsorbent–adsorbate were established for the investigated adsorbents in the temperature range between 0 and 100°C. It was found that the isotherms belong in all the cases to type I, and that they can be adequately described by the Freundlich isotherm equation in the domain which is of importance from the aspect of further investigations. An attempt was made to describe the reversible equilibrium process of solid–gas systems with the aid of the available adsorption theories. The polymolecular adsorption mechanism which takes place on the surface of small-surfaced, unconventional, and, in respect to the energetic conditions of adsorption gases, inhomogeneous adsorbents cannot be treated in a way analogous to the simplified methods evolved for conventional adsorbents. On the other hand, uranium hexafluoride as an adsorbate is a quite particular substance from the aspect of its macroscopic and molecular properties, and thus, not only the description of the adsorbed layer but also the determination of the fundamental physical constants, such as the surface requirement of the molecule, proved to be rather difficult. (auth)

**19722** MEAN AMPLITUDES OF VIBRATION FOR DIBORANE AND DEUTERODIBORANE. Cyvin, S. J.; Vizi, B. (Technical Univ. of Norway, Trondheim. Univ. for Chemical Industries, Veszprem, Hungary). Acta Chim. Acad. Sci. Hung., 59: 85-90 (1969).

A normal-coordinate analysis was performed for isotopic diboranes. The developed harmonic force field was used to calculate the mean amplitudes of vibration for some isotopic species of diborane. These results were compared with electron-diffraction values of mean amplitudes, and some significant discrepancies are pointed out. (auth)

**19723** DIAMOND-WINDOWED CELL FOR SPECTROPHOTOMETRY OF MOLTEN FLUORIDE SALTS. Toth, L. M.; Young, J. P.; Smith, G. P. (Oak Ridge National Lab., Tenn.). Anal. Chem., 41: 683-5(Apr. 1969).

A design of a diamond-windowed cell for spectrophotometry of molten fluoride salts is described that is of simple construction and can be easily taken apart for cleaning. It has a graphite body and is, of course, limited to use with systems that are inert toward carbon. To illustrate the capability of the cell the spectrum of pure $LiF-BeF_2$ plus cell and the solute spectrum of a dilute solution of $NiF_2$ in $LiF-BeF_2$ at 550°C were investigated. The latter spectrum was similar to that observed in windowless containers. The solute spectrum of a dilute solution of $UF_4$ in $LiF-BeF_2$ at 550°C was also studied. The weak band at 2.03 $\mu$ in this spectrum of U(IV) was not observed in previous measurements with a windowless cell because it could not be distinguished from a gradual variation in the base line. The existence of such a band was predicted and its observation with the diamond-windowed cell helps confirm the value of the device. (D.H.M.)

**19724** THERMODYNAMIC PROPERTIES IN THE SYSTEMS VANADIUM–HYDROGEN, NIOBIUM–HYDROGEN, AND TANTALUM–HYDROGEN. Veleckis, Ewald; Edwards, Russell K. (Illinois Inst. of Tech, Chicago). J. Phys. Chem., 73: 683-92(Mar. 1969).

Comprehensive thermodynamic studies were conducted for the systems V–H (246 to 554°), Nb–H (352 to 671°), and Ta–H (350 to 631°) in the pressure range 1 to 800 torr by measuring the equilibrium hydrogen pressure as a function of composition. Each of these systems is comprised of a single solid phase in the temperature and pressure ranges studied. For each system a semiempirical equation, based on the statistical formulation of the simple interstitial solid solution model, is presented. The equations not only adequately reproduce the pressure-composition-temperature (P–C–T) data within the ranges of study but appear to be reliable to much lower temperatures. For example, they have been used to predict the T–C boundaries of immiscibility regions; for one system (Nb–H), for which comparison with an experimentally derived diagram is possible, agreement is very good. Calculated critical compositions, temperatures, and pressures are given. The partial and integral entropies and enthalpies of formation were calculated for the single-phase regions at 1 at. % intervals up to the maximum compositions of 34 (V–H), 39 (Nb–H), and 27 (Ta–H) at. % H. The results are compared in detail with those of other work. (auth)

**19725** COMPLEX COMBINATIONS OF TETRAVALENT THORIUM. I. Poni, M.; Bold, A.; Sirghie, I. An. Stiint. Univ. Al. I. Cuza Iasi, Sect. Ic. Chim., 13: No. 1, 15-18(1967). (In Rumanian).

Six complexes of tetravalent thorium were synthetized. Aurintricarboxylic acid, pyridine, $\beta$-picoline, $\gamma$-picoline, 2,6-lutidine, and piperidine complexing agents were used. The methods used for the preparation of the complexes are indicated together with the chemical analyses performed. (Rom. Sci. Abstr.)

**19726** TRITIUM–HYDROGEN EXCHANGE STUDIES OF PROTEIN MODELS. I. GRAMICIDIN S-A. Laiken, S. L.; Printz, M. P.; Craig, L. C. (Rockefeller Univ., New York). Biochemistry, 8: 519-26(Feb. 1969).

Tritium–hydrogen exchange experiments, using a new rapid dialysis technique, were performed on the cyclic decapeptide gramicidin S-A in aqueous solution. The technique, countercurrent dialysis, was found to give highly accurate results and should have general applicability to exchange measurements. The molecule has eight exchangeable peptide hydrogens, all of which may be followed in the $pH_{min}$ region. Slowly exchanging peptide hydrogens are clearly present. In the base-catalyzed region, there are four rapidly exchanging hydrogens and two groups of two slow hydrogens each, the slowest of which exchange more than an order of magnitude more slowly than those of poly-DL-alanine. In the acid-catalyzed region, there are again four slow hydrogens, but they are found in one kinetic class. The results for the pH dependence of the exchange rate are consistent with an $EX_2$ mechanism of exchange. This fact constitutes important evidence for the validity of this mechanism since gramicidin S-A, with respect to exchange, is a much simpler system than a protein. The free energies of the opening reactions are calculated to be about 0.483 and 1.73 kcal per mole for the two slow classes in the base-catalyzed region. Since the energy of the molecule was estimated to be of the order of −100 kcal mole, it is clear that the conformational changes needed to allow the slow hydrogens to exchange are not major ones and perhaps involve only small rotations about bonds. Data for exchange in aqueous solution are found to agree quite well with NMR data obtained in methanol and dimethyl sulfoxide, thus implying that the primary conformational determinants of this molecule are steric effects and backbone energetics. Finally, the results are shown to be consistent with one of the possible models of gramicidin S-A proposed earlier. (auth)

**19727** HYDROGEN-EXCHANGE MEASUREMENTS ON ESCHERICHIA COLI TRANSFER RIBONUCLEIC ACID BEFORE, AFTER, AND DURING ITS AMINOACYLATION. Gantt, R. R.; Englander, S. W.; Simpson, Melvin V. (Dartmouth Medical School, Hanover, N. H.). Biochemistry, 8: 475-82(Feb. 1969).

The conformation of transfer ribonucleic acid was compared with aminoacyl transfer ribonucleic acid by using the Sephadex hydrogen–tritium exchange technique. The exchange kinetics of the acylated and unacylated transfer ribonucleic acid are almost identical, suggesting that secondary structures are closely similar. However, a small but consistent difference was observed. The aminoacyl transfer ribonucleic acid seems to possess three or four more stabilized hydrogens than the unacylated transfer ribonucleic acid, representing approximately 4% the measurable structure. Thus, the aminoacyl transfer ribonucleic acid has at least as much structure involving hydrogen bonds as has unacylated transfer ribonucleic acid and perhaps slightly more. In addition, a new application of hydrogen exchange is described. It was possible to carry out measurements that should detect changes in transfer ribonucleic acid structure that might occur during the transient interval in which it binds to the amino acid–adenosine monophosphate–synthetase complex, undergoes acylation, and then dissociates. (auth)

**19728** LOW FREQUENCY PHONONS IN NAPHTHALENE. Pawley, G. S.; Yeats, Elizabeth A. (Univ. of Edinburgh). Solid State Commun., 7: 385-8(Feb. 1969).

Using neutron inelastic scattering some phonons of anomalously low frequency in perdeuteronaphthalene were observed. This supports previously reported results from vibronic transitions studies. These phonons occur near the Brillouin zone boundary and therefore would contribute pronounced peaks in the density of phonon states, at about 10 $cm^{-1}$ and 30 $cm^{-1}$. The form of molecular motion in these phonons was not identified. (auth) (UK)

**19729** PROTON AND DEUTERON MAGNETIC RESONANCE IN PARTLY DEUTERATED CRYSTALS. III. GYPSUM. Hutton, Gary (Univ. of Oslo); Pedersen, Bjoern. J. Phys. Chem. Solids, 30: 235-42(Feb. 1969).

Single crystals of gypsum containing approximately 50% deuterium were made by heating natural gypsum crystals in heavy water at 110°C for 24 hr, and the room temperature D MR- and P MR-spectra of these partly deuterated crystals were analyzed in detail. The water molecules are flipping fast at room temperature making the two deuterons in each molecule magnetically equivalent. The quadrupole coupling constant was found to be 118.3 ± 0.7 kHz and the asymmetry factor 0.877 ± 0.009. The directions of the principal axes are closely related to the orientation of the water molecule as given by neutron diffraction. From the hyperfine structure in the DMR-spectra and the second moments of the PMR-spectra the mole fractions of $H_2O$, HDO and $D_2O$ molecules in the crystal were derived. The deuteron distribution in the crystal was found to be different from a random distribution on the available sites. The data indicate that the molecular distribution within the crystal is random, but intermolecular proton–deuteron exchange does not seem to take place inside the crystal to a measurable extent. (auth) (UK)

**19730** ISOTOPE EFFECTS ON THE FLUORESCENCE OF AMINOPHTHALIMIDE. Foerster, Th.; Rokos, K. (Univ., Stuttgart). Z. Phys. Chem. (Frankfurt), 63: 208-11(Jan. 1969). (In German).

Relative increases in the fluorescence yield from aminophthalimide caused by deuterium incorporation in the solvent are shown. (M.C.G.)

**19731** PRIMARY KINETIC ISOTOPE EFFECTS IN THE DEHYDRATION OF ALCOHOLS ON $Al_2O_3$. Knoezinger, H.; Scheglila, A. (Univ., Munich). Z. Phys. Chem. (Frankfurt), 63: 197-8(Jan. 1969). (In German).

Primary kinetic isotope effects were observed in the dehydration of deuterated alcohols. The size of the effect decreased with increasing temperature. (M.C.G.)

**19732** STUDIES ON REMOVAL OF RADIOIODINE BY ACTIVATED CARBON. I. ADSORPTION OF IODINE AND METHYL-IODIDE ON ACTIVATED CARBON. Murata, Toshifumi; Kamiya, Kunio (Hitachi Ltd., Japan). Nippon Genshiryoku Gakkaishi, 11: 138-43(1969). (In Japanese).

In order to obtain adsorption data for iodine and methyl iodide at low partial pressures, helium gas containing iodine or methyl iodide was passed through a small activated carbon bed, and the amount of iodine and methyl iodide adsorbed was measured. The specific adsorption of both iodine and methyl iodide at temperatures from 50 to 400°C was determined, together with the rate of desorption and the amounts irreversibly adsorbed. From these

results it was found that the rate of adsorption can be expressed by the equation given by Bangham, and the isotherms by that of Freundlich. The differential heats of adsorption were obtained through the use of the Clausius–Clapeyron equation. (auth)

**19733** MECHANISM OF ION EXCHANGE WITH ALGINIC ACID. Cozzi, D.; Desideri, P. G.; Lepri, L. (Univ. of Florence). J. Chromatogr., 40: 130-7(Mar. 11, 1969).

The exchange mechanism which determines the retention capacity of alginic acid has been investigated. Chromatographic, pH, and viscosity measurements, performed with several metal ions, showed that ion exchange is not the only mechanism but that the influence of the two vicinal hydroxyl groups on the retension capacity of alginic acid is also important. The metals studied included: Ag, Ca, Ba, Cd, Cu, Ga, In, Mg, Ni, Pb, Sr, Tl, Th, Zn, Cs, Be, Mn, Ce, and Cr. (P.C.H.)

**19734** THE SOLID REACTION PRODUCTS OF THE CATALYTIC DECOMPOSITION OF CARBON MONOXIDE ON IRON AT 550°C. Ruston, W. R.; Warzee, M.; Hennaut, J.; Waty, J. (SERAISC, Brussels). Carbon, 7: 47-57(Feb. 1969).

The catalytic decomposition of CO on iron surfaces at 550°C was studied by optical methods, internal friction measurements, x-ray diffraction, and electron microscopy. Carburization of the bulk of the metal takes place by interstitial diffusion of C atoms with precipitation of cementite when the solution becomes supersaturated; this affects the mechanical stability of the metal. Two types of carbon are generally found on the surface of the samples after exposure to CO. The first is a lamellar form of carbon located close to the metal surface and arising probably from decomposing $Fe_3C$ crystals in the surface. The second is a filamentous form which originates from small crystals of a particular iron carbide epitaxially grown on the surface of metal grains. These small crystals also develop on the surface of decomposing $Fe_3C$ crystals. X-ray diffraction studies showed this iron carbide to be $Fe_7C_3$. Electron microscopy of the carbon filaments showed a small crystal of $Fe_7C_3$ which acted as a growth center for each filament. The decomposition of CO is catalyzed by iron as well as by $Fe_7C_3$. Cementite probably does not catalyze the reaction. (auth) (UK)

**19735** CONTINUITIES IN THE SPECTRA AND STRUCTURE OF THE ACTINYL IONS. Bell, J. T. (Oak Ridge National Lab., Tenn.). J. Inorg. Nucl. Chem., 31: 703-10(Mar. 1969).

The band positions of the uranyl absorption spectrum were diagramed to indicate the relative energy levels of the nonbonding orbitals for a molecular orbital model for the uranyl ion which has been defined as the actinyl core. The band positions of the transuranium actinyl spectra were compared with the spacings between the positions of the uranyl bands. The results indicate that a single molecular orbital model can represent any of the actinyl ions when the uranyl ion is assumed to have the bonding orbitals exactly filled and the transuranium actinyl ions are represented with the actinyl core and a progressive increase of electrons in the first two orbitals lying above the bonding orbitals. (auth) (UK)

**19736** PMR AND MAGNETIC SUSCEPTIBILITY OF URANIUM(V) PENTAETHOXIDE. Karraker, D. G.; Siddall III, T. H.; Stewart, W. E. (E. I. du Pont de Nemours and Co., Aiken, S. C.). J. Inorg. Nucl. Chem., 31: 711-14(Mar. 1969).

PMR studies of $[U(OC_2H_5)_5]_2$ in $CFCl_3$ and $CDCl_3$ solutions indicate that from −65°C to room temperature the structure of the dimer involves a double alkoxide bridge and 6-coordinated U(V) ions. At lower temperatures the complexity of PMR spectra was interpreted as demonstrating an increase in molecular complexity. The PMR spectra of U(V) pentaisopropoxide in $CDCl_3$ were explained as due to a mixture of monomer and dimers at room temperature, and only dimers at low temperatures. The anomalously low magnetic susceptibility of $[U(OC_2H_5)_5]_2$, 1.12 BM vs 1.73 BM for spin-only and 2.54 BM for 5 $f^1$ paramagnetism, is proposed to be the result of spin interaction between U(V) ions in the $[U(OC_2H_5)_5]_2$ dimer. (auth) (UK)

**19737** NEUTRON INELASTIC SCATTERING AND X-RAY STUDIES OF AQUEOUS SOLUTIONS OF DIMETHYLSULPHOXIDE AND DIMETHYLSULPHONE. Safford, G. J. (Union Carbide Corp., Tuxedo, N. Y.); Schaffer, P. C.; Leung, P. S.; Doebbler, G. F.; Brady, George W.; Lyden, E. F. X. J. Chem. Phys., 50: 2140-59(Mar. 1, 1969).

Molecular vibrations in solid and liquid dimethylsulfoxide (DMSO) and dimethylsulfone ($DMSO_2$) have been measured by neutron inelastic scattering between 900−8 $cm^{-1}$. Neutron spectra of the intermolecular frequencies of water molecules in aqueous solutions of perdeuterated DMSO and $DMSO_2$ have also been measured to determine, as a function of concentration and of temperature, the influence of these compounds on the water structure. In addition, the broadening of the incident energy distribution by diffusive motions of $H_2O$ molecules has also been investigated. The similarity of intermolecular frequencies in the spectra of both the liquid and solid phases of the pure compounds shows a high degree of dipole association. In dilute aqueous solutions the DMSO and $DMSO_2$ (hydrogenous and perdeuterated) both cause a similar enhancement and sharpening of the intermolecular frequencies of the water structure associated with a small and cooperative perturbation in the orientation of many $H_2O$ molecules. This is consistent with the x-ray radial distribution which shows a corresponding small enhancement of the peaks of pure water out to 8 Å. As the concentration of DMSO is raised, the existing water structure is broken down due to the formation of hydrogen-bonded, thermolabile, DMSO−$H_2O$ complexes. The angular and temperature dependences of the diffusively broadened incident energy distribution are both in accord with delayed or jump diffusion. At low concentrations, the residence times and the self-diffusion coefficients of $H_2O$ molecules in both DMSO and $DMSO_2$ solutions are similar to those for pure water. At higher concentrations of DMSO, the increased formation of the hydrogen-bonded complexes causes a decrease in the self-diffusion coefficient and an increase in the delay or residence time for water molecules. Both neutron spectra and x-ray data indicate that the dipole interactions and hydrogen bonding of DMSO inhibit the formation of hexagonal ice upon freezing; this may account for the cryoprotective properties of DMSO. (auth)

**19738** CHELATES OF URANYL IONS WITH COMPLEXING AGENTS. Frausto da Silva, J. J. R.; Silmoes, M. Lourdes Sadler; Legrand de Moura, M. (Instituto de Alta Cultura, Lisbon). Mem. Acad. Cienc. Lisboa Cl. Cienc., 11: 31-42(1967). (In Portuguese).

The chelating of uranyl ions with polyaminocarboxylic acids was studied in order to determine the characteristics of those ligands which most affect the stability of the complexes. The results showed that the ideal complexing agent would have a linear chain with five or six donor atoms, preferably charged but not contributing much to the total basicity of the complexing agent. (J.S.R.)

**19739** STABILITY CONSTANTS OF SOME URANYL COMPLEXES. II. Ramamoorthy, S.; Santappa, M. (Univ. of Madras). Bull. Chem. Soc. Jap., 42: 411-16(Feb. 1969).

Stability constants of complexes of uranyl ions with various carboxylic acids were determined by the pH titration method at 31°C and $\mu = 0.1$ ($NaClO_4$) in the pH range 2.5 to 3.5. The 1:1 and 1:2 complexes were formed with crotonic, pyruvic, malonic, and diglycolic acids and only the 1:1 complex with formic, propionic, succinic, adipic, maleic, and tumaric acids. The effect of ring size and presence of oxygen atom as keto or ether oxygen or that of double bonds in the ligand acids on the stabilities of the corresponding complexes are discussed. (auth)

**19740** STABILITY CONSTANTS OF Np(V) ION COMPLEXES WITH α-HYDROXYCARBOXYLIC ACIDS. Eberle, S. H.; Schaefer, J. B. (Univ., Karlsruhe, Ger. Kernforschungszentrum, Karlsruhe, Ger.). J. Inorg. Nucl. Chem., 31: 1523-7(May 1969). (In German).

The complexes with five acids in the series from glycolic to α-hydroxycaproic acid were examined by absorption spectroscopy. The extinction was measured at selected wavelengths for various pH values and the stability constants calculated therefrom. Only single-ligand complexes were observed. The stability constants were quite low (range 30 to 60) compared with those for U and Pu, but high compared with Ag and with the value for acetate. Explanations of these relations are suggested. (UK)

**19741** LONG-RANGE DEUTERIUM ISOTOPE EFFECTS ON CHEMICAL SHIFTS. Allred, A. L.; Wilk, W. D. (Northwestern Univ., Evanston, Ill.). J. Chem. Soc., D, No. 6, 273(Mar. 19, 1969).

It is stated that while there are numerous examples of deuterium isotope shifts in NMR involving nuclei separated by two bonds in saturated compounds, or separated by several bonds in unsaturated compounds, reports of such shifts through three saturated bonds are sparse. With a view to determining if the effect persists over a longer range, and to gain information about its origin, the shifts of a series of deuterated saturated hydrocarbons were measured. An upfield shift was observed for 2, 3 and 4σ-bond separations, but no shift was found with a 5-bond separation. It was concluded that the deuterium isotope shift is clearly not due to protium and deuterium having different inductive effects. (UK)

# Radiation and Nuclear Chemistry

*Refer also to abstracts 19902, 20049, 21330, and 21451.*

**19742** (BNL-13423) DEPENDENCE OF THE THERMAL DECOMPOSITION INDUCTION PERIOD ON PRIOR γ- AND X-RAY IRRADIATION. Herley, P. J. (Picatinny Arsenal, Dover, N. J.); Levy, P. W. (Brookhaven National Lab., Upton, N. Y.). [1969]. 19p. (CONF-690405-1). Dep. CFSTI.

From Meeting of the Western States Section, The Combustion Institute, China Lake, Calif.

This relation describes the ammonium perchlorate results over a dose range of $10^2$ to $10^7$ R. In order to relate it to both thermal decomposition kinetics and radioinduced processes (induction period) vs. (total dose) equations were derived for a variety of different conditions. These represent combinations of the linear, power law, and exponential induction period kinetics and linear, exponential, and saturating exponential nuclei growth kinetics during irradiation. In addition it is necessary to make assumptions about the induction period processes. The most important are: Before heating the material contains a fixed number of potential nuclei forming sites, which increase in size during heating until they reach a critical size. Having attained this size the induction period process is superseded by one of the acceleratory period processes. It is also assumed that the radioinduced and thermally induced nuclei growth kinetics may be different. These conditions lead to nine different (induction period) vs. (total dose) equations. Only one of these, the equation for exponential nuclei growth during heating and linear nuclei growth during irradiation, corresponds to the experimentally observed relation. (auth)

**19743** (COO-1617-14) REACTIONS OF HALOGEN ATOMS ACTIVATED BY NUCLEAR PROCESSES WITH ORGANIC MEDIA AT 77° AND 298°K. Lambrecht, Richard Merle (Nebraska Univ., Lincoln. Dept. of Chemistry). Jan. 31, 1969. Contract AT(11-1)-1617. 173p. Dep. CFSTI.

Thesis.

The chemical reactions initiated by the $^{130m}I(IT)^{130}I$ and $^{82m}Br(IT)^{82}Br$ processes were investigated and compared with those induced by the $^{129}I(n,\gamma)\ ^{130}I + {}^{130m}I$, $^{127}I(n,\gamma)^{128}I$, $^{37}Cl(n,\gamma)^{38}Cl$, and the $^{81}Br(n,\gamma)^{82}Br + {}^{82m}Br$ nuclear transformations. The organic yields of $^{130}I + {}^{130m}I$ and $^{128}I$ activated by radiative neutron capture were compared to those of $^{130}I$ activated by isomeric transition in several liquid hydrocarbons ranging from n-pentane to n-nonane. The organic yields of (n,γ) activated $^{130m}I + {}^{130}I$ are consistently lower than the (IT) induced organic yields of $^{130}I$ and (n,γ) activated $^{128}I$. Radiogas chromatography analysis indicated the similarity of products, but differences in abundance of the relative product yields of $^{128}I$, $^{130}I$, and $^{82}Br$. The (n,γ) and (IT) activated reactions of bromine were studied in various liquid hydrocarbons ranging from pentane to tridecane. The total organic yields of (n,γ) activated $^{80m}Br$ were lower than the (IT) organic yields of $^{82}Br$ at all $Br_2$ concentrations studied. The organic yields were found to vary with the chain length and the target molecule structure. The organic yields from $I_2$, $Br_2$, and ICl source molecules activated by radiative neutron capture and isomeric transition were determined in polycrystalline n-hexane, cyclohexane, and 2,2-dimethylbutane, and in glassy 3-methylpentane at 77°K. Specifically the effects of purity levels, neutron irradiation and post-irradiation procedures, halogen concentration, additives, and nuclear transformation on the observed organic yields were investigated. The experiments with $Br_2$, $I_2$, and ICl (in which either halogen atom may acquire a radioactive label) indicated that the radiohalogens mainly trace their environment without chemical selectivity with regard to isotope and mode of activation. In glassy and polycrystalline halogen–hydrocarbon systems, the organic yields under the conditions of monomolecular dispersion are about 55 ± 5%. In polycrystalline hydrocarbons containing $I_2$, or ICl, rather constant organic yields of about 10% in n-hexane, and 2,2-dimethylbutane, and 25% in cyclohexane between $1 \times 10^{-5}$ and $2 \times 10^{-4}$ mf halogen suggests the formation of preferred $(X_2)_n$ cluster sizes and/or similar numbers of halogen molecules at sites in the hydrocarbon matrix. The effects of phase change on $^{130m}I(IT)^{130}I$ and the $^{82m}Br(IT)^{82}Br$ induced organic yields were explored. The complicating role of isomeric-transition-induced reactions in neutron activation analysis for $^{82}Br$ and $^{130}I$ is discussed. (J.G.B.)

**19744** (EUR-3940-2) RESEARCH AT ISPRA, 1961–1967. PART II. NUCLEAR MATERIALS. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1968. 176p. UK $6.00.

Research progress is reported on: radiation chemistry of organic coolants, analytical chemistry of nuclear materials, activation analysis, nuclear fuel processing, basic research on nuclear materials, SAP and other Al-base dispersed-phase alloys, Zircaloy and graphite, and uranium fuels and compatibility problems. (M.C.G.)

**19745** (EUR-4215) SUBSTITUTED CYCLOOLEFINS AND PARTIALLY HYDROGENATED BIPHENYLS. Sandroni, S. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center); Beaudet, C. (Societe d'Etudes, de Recherches et d'Applications pour l'Industrie, Brussels (Belgium)); Juppe, G. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). Oct. 15, 1968. 38p. Dep.

For a better understanding of the pyrolytic and radiolytic behavior of partially hydrogenated polyphenyls larger amounts of high purity 1-phenylcyclohexene, 3-phenylcyclohexene, 4-phenylcyclohexene, 1-, 3- and 4-methylcyclohexene, 1-methylcyclopentene, 1-methylcycloheptene, 1, 3- and 1,4-cyclohexadienes were synthesized and the compounds characterized by their ultraviolet, infrared, Raman, and nuclear magnetic resonance absorptions. From spectral correlations a 2,5-phenylcyclohexadiene structure was assigned to the Birch reduction product of biphenyl with sodium. (auth)

**19746** (TID-25000) STUDY OF FISSION PRODUCT RHODIUM AS A POTENTIAL COMPONENT OF PLATINUM–RHODIUM ALLOY FOR USE IN PRODUCTION OF NITRIC ACID FROM AMMONIA. [Cohn, J. G.] (Engelhard Industries, Newark, N. J. Research and Development Dept.). [Mar. 26, 1969]. 9p. Dep. CFSTI.

Eleven-year old fission product rhodium was converted at the Pacific Northwest Laboratories of Battelle Memorial Institute to 10% rhodium–90% platinum alloy in the form of a foil of 0.003-inch thickness. Greater than 98% of the radioactivity in the alloy was due to $^{102m}Rh$. The only significant non-rhodium activity detected was $^{106}Ru$. The dose rate from the gamma activity was 2 mR at a source to detector distance of 5 cm from the sheet of alloy containing 4.2 grams of rhodium. Testing of the alloy at Engelhard Industries as catalyst in ammonia oxidation to produce nitric acid showed that the alloy should be suitable for this service. Radiochemical testing at Battelle after completion of the catalytic testing showed no significant change in activity. (auth)

**19747** RADIOLYSIS OF NON-POLAR ORGANIC LIQUID MIXTURES. Kroh, Jerzy; Karolczak, Stefan (Technical Univ., Lodz, Poland). Radiat. Res. Rev., 1: 411-70(Feb. 1969).

The radiation chemistry of non-polar organic liquids mixtures is reviewed; topics discussed include deposition, localization, and transfer of energy. The systems investigated include mixtures of saturated hydrocarbons, mixtures of saturated and unsaturated hydrocarbons, mixtures with one aromatic component, mixtures of aromatic hydrocarbons, and mixtures with $CCl_4$ as a component. Radioinduced isomerization is also considered. (260 references). (D.H.M.)

**19748** RADIATION CHEMISTRY OF ALCOHOLS, ETHERS, AND KETONES IN CONDENSED STATES. Teply, Jiri (Inst. of Nuclear Research, Rez, Czech.). Radiat. Res. Rev., 1: 361-410(Feb. 1969).

The radiation chemistry of alcohols (liquid and solid state) polyalcohols, ethers (liquid and solid state), ketones, (liquid and solid state), and aldehydes is reviewed. Some topics discussed include, primary processes, gaseous products, and liquid products and also products from aliphatic, cyclic, and deuterated compounds. (210 references). (D.H.M.)

**19749** INVESTIGATIONS IN THE FIELD OF RADIATION-INDUCED SOLID-STATE POLYMERIZATION. PART XVII. THE POLYMERIZATION OF 5-CARBOXY-BICYCLO-(2,2,1)-HEPTENE-(2) AND ITS COPOLYMERIZATION WITH MALEIC ANHYDRIDE. Hardy, Gy; Nyitrai, K.; Sarlo, Cs. (Polytechnical Univ., Budapest). Period. Polytech. Chem. Eng., 12: 13-24(1968).

The radioinduced polymerization and copolymerization of norbornenecarboxylic acid in the liquid and in the solid phase was studied. In the liquid phase polymerization kinetics has a linear character, the rate is proportional to the first power of the dose rate, and the activation energy from the temperature dependence of the polymerization rates, $E_p - \frac{1}{2}E_t$, is 2.52 Kcal/mole. Polymerization in the liquid phase is inhibited by typical inhibitors of radical mechanisms. The kinetic character by solid-phase polymerization is linear; the rate of polymerization changes proportionally to the first power of the dose rate. Changes in polymerization rate with temperature in the different phases were studied. In the liquid phase the rate decreases with decreasing temperature; in the solid phase it passes through a maximum, which is characteristically not in the vicinity of the melting point, but about 10°C lower, around 30°C. The possible

transformation of the solid monomer was studied by differential thermal analysis. Phase transformation appears quite clearly around 30°C in the solid monomer; its nature is still under investigation. Postpolymerization of norbornenecarboxylic acid was studied after preliminary irradiation at −78°C and post-polymerization in the solid phase at 20°, 30°, and 35°C. Under these conditions no polymers were formed. Copolymerization with maleic anhydride was also studied; the structure of the copolymer was investigated by 3 methods. Copolymerization also has linear kinetics. The 2-component solid system forms an eutectic with a corresponding change in copolymerization rate; the composition of the copolymer points to a significant self-addition of maleic anhydride. (BBB)

**19750** STABILIZATION OF DEFECT CHARGE STATES IN SOLIDS. Wertheim, G. K.; Buchanan, D. N. E. (Bell Telephone Labs., Inc., Murray Hill, N. J.). Chem. Phys. Lett., 3: 87-9(Feb. 1969).

Electron and gamma radiation experiments in ferrous ammonium sulfate and other compounds show that the stabilization of $Fe^{3+}$ following the decay of $^{57}Co^{2+}$ in hydrated salts is due to the radiolysis of water by Auger electrons. (auth)

**19751** TIME DEPENDENCE OF ION-PAIR RECOMBINATION RATES IN LIQUIDS OF LOW DIELECTRIC CONSTANT. Ludwig, Peter K. (Univ. of Notre Dame, Ind.). J. Chem. Phys., 50: 1787-93(Feb. 15, 1969). (COO-38-631).

An analog computer method is employed to solve the differential equation of diffusion when applied to ensembles of isolated ion pairs. The method permits evaluation of the probability density of the ion pairs as well as relative rates of their neutralization as function of time for a variety of initial conditions. The results are discussed with emphasis on ion neutralization processes in radiation chemistry. (auth)

**19752** RADIATION- AND ULTRAVIOLET-INDUCED REACTIONS OF CAFFEINE WITH ALCOHOLS. Elad, D.; Rosenthal, I.; Steinmaus, H. (Weizmann Inst. of Science, Rehovoth, Israel). Chem. Commun., No. 6, 305-6(Mar. 19, 1969).

It was found that the reactions could be induced directly, or sensitized radiolytically or photochemically with a ketone (acetone), leading to substitution products at the purine 8-position with yields of up to 80%. With propan-2-ol both the γ-ray induced and the photochemical reactions led to dimethylcarbinol, whereas with ethanol the γ-induced reaction led to a methylcarbinol and 8-ethylcaffeine in 1:1 ratio but the photochemical reaction led only to 8-ethylcaffeine. The products were isolated by chromatography on silica gel and identified by elemental analysis, ir, NMR, and mass spectra. (UK)

**19753** INFLUENCE OF pH ON YIELD OF HYDROGEN ATOMS IN RADIOLYSIS OF AQUEOUS SOLUTIONS. Moreau, M.; Sutton, J. (CEN, Saclay, France). Trans. Faraday Soc., 65: 380-9(Feb. 1969).

The effect of pH on the yield of radiolytically-produced hydrogen atoms was studied in aqueous solutions containing low concentrations of solutes RH, which react with H atoms to give $H_2$. All the data up to pH 13.5 can be explained in terms of a competition between RH (plus its anion for alcohols) and $OH^-$ for a hydrogen atom yield of $G(H) = 0.50 \pm 0.05$. This result indicates that, contrary to the spur diffusion model, an intraspur reaction, $e^-_{aq} + H_3O^+ \rightarrow H + H_2O$, is not the source of this important fraction of the hydrogen atom yield. (auth) (UK)

**19754** INVESTIGATIONS IN THE FIELD OF RADIATION-INDUCED SOLID STATE POLYMERIZATION. XXIV. THE POLYMERIZATION OF CETYL VINYL ETHER. Hardy, Gyula; Nyitrai, Karoly; Cser, Ferenc; Cselik, Gyoergy; Nagy, Istvan (Muanyagipari Kutato Intezet, Budapest). Magy. Kem. Foly., 74: 602-7(Dec. 1968). (In Hungarian).

Cetyl vinyl ether has a smectic liquid crystalline state between its mp (16.5°C) and −2.5°C. Below this temperature range, the compound has two different solid crystalline states with a phase transition point at −16°C. Solid-state polymerizations carried out with the latter two systems gave linear kinetical curves, but the curves obtained with the liquid crystalline phase were of the accelerating type. This latter can be explained by the fact that the polymer formed does not have a destructive effect on the crystal lattice, but on the contrary, it stabilizes the regular smectic structure. The transition from the liquid crystalline state into a three-dimensional crystalline structure takes several hours, therefore, it is possible to carry out an accelerating type polymerization, corresponding to the liquid crystalline structure, even below −2.5°C. The polymerization probably occurs by cationic mechanism. The polymers obtained show an optical birefringence and melt sharply at 36°C. Their structures reflect that of the monomeric matrix. This feature disappears only after the system has been melted. The DP of the polymers does not depend on the polymerization parameters (temperature, dose rate), but reflects the sizes of the crystal sections, which are perfect from the point of view of linking during polymerization. (auth)

**19755** COMPOSITION OF GRAFT COPOLYMERS FORMED BY ELECTRON IRRADIATION. Hinsch, J. E.; Curro, J. G. (Ford Motor Co., Dearborn, Mich.). Macromolecules, 1: 405-8(Sept.-Oct. 1968).

In the radioinduced grafting to an elastomer, it is expected that for a 2 component comonomer system-to-elastomer graft, the well-known copolymer composition equation can be used directly to ascertain the composition of the product. This is true provided the following conditions or assumptions are valid: transfer reactions and elastomer-elastomer addition reactions can be neglected; the true monomer ratio in the polymer phase is used; and during copolymerization there are no diffusion or phase change limitations. Vinyl monomers, acrylic acid, and 1H,1H-dodecafluoroheptyl acrylate were grafted to an ethylene−propylene copolymer substrate. Samples were irradiated with 0.25-MeV electrons for a total dose of 184 Mrad, yielding grafts of less than 10% conversion of monomer. The measured ratios of acrylic acid to $C_7$ ester found in the graft system were plotted as a function of the monomer ratio of the initial graft solution. Experimental results indicate a higher fraction of grafted acrylic acid than predicted, suggesting perhaps that the acrylic acid monomer is more soluble in the rubber than the $C_7$ ester or perhaps a chain-transfer mechanism is influencing the observed graft composition. The influence of mutual solubility of the vinyl monomers on the calculated composition was also considered. (BBB)

**19756** GRAFTING OF ACRYLONITRILE AND STYRENE ONTO POLYVINYL CHLORIDE USING HIGH-ENERGY RADIATION. Chapiro, Adolphe; Jendrychowska-Bonamour, Anna-Maria (to Centre Nationale de la Recherche Scientifique). U. S. Patent 3,433,724. Mar. 18, 1969. Priority date June 23, 1963, France.

A process for grafting a mixture of acrylonitrile and styrene onto a polyvinyl chloride backbone is described. The grafter mixture contains 50 to 99%, preferably 75 to 99%, by volume acrylonitrile. (TSS) (Offic. Gaz.)

**19757** RADIOLYSIS OF PEPTIDES AND PROTEINS. Wheeler, Owen H. (Puerto Rico Nuclear Center, Mayaguez). Photochem. Photobiol., 7: 675-81(June 1968).

Studies on peptides indicated that the mechanism of their radiolysis is similar to that of amino acids. Recent work indicates that the nature of the amino acid affects the resistance of the peptide linkage. Aromatic rings are also hydroxylated in preference to attack on the peptide group. The products were identified and analyzed using carbon-14-labeled peptides. The radiation protection effects of a series of organic compounds were determined by competition for hydroxyl radicals with the labeled peptide. Comparison was made between the radiolysis and photolysis of peptides. (auth)

**19758** THE PREPARATION OF $^{135}Xe$ SAMPLES FOR MEDICAL PURPOSES. Fritze, K.; Robertson, R. (McMaster Univ., Hamilton, Ont.). Radiochim. Acta, 9: 221-2(Oct. 1968).

A method for production of $^{135}Xe$ that can be used in any reactor and does not need a specific "in-core" facility is described. $^{235}U$ is deposited on an aluminum foil from a uranyl nitrate solution. The foil is rolled into a small ball and heated. It is then irradiated and cooled. Heating the sample in a vacuum releases the $^{135}Xe$. Radiochemical purity of the xenon was better than 99.9%. The yield was approximately 80%. (M.C.G.)

**19759** TAKASAKI: SECOND GENERATION OF RADIATION CHEMISTRY. [PART II]. Puig, Jean-Rene (Centre d'Etudes Nucleaires, Saclay, France). Ind. At., 13: No. 1-2, 41-50(1969). (In French).

The achievements of Japan in the field of basic and applied research in radiation chemistry are considered. All the modes of application of intense radiations that are being worked out there are described. All the phases of research are handled in this center. (M.C.G.)

**19760** ION RADICALS OF STYRENE IN IRRADIATED ORGANIC GLASSES STUDIED BY ELECTRON SPIN RESONANCE. Iwamoto, Takeo (Kyoto Univ.); Hayashi, Koichiro; Okamura, Seizo; Hayashi, Kanae; Yoshida, Hiroshi. Int. J. Radiat. Phys. Chem., 1: 1-9(Jan. 1969).

In connection with study of the correlation between active species formed from styrene by radiation and its radioinduced polymerization, irradiated organic glasses containing styrene were examined by the electron spin resonance method at 77°K. In 2-methyltetrahydrofuran glass, anion radicals of styrene were formed by the

transfer of electrons ejected by radiation from the glass matrix molecules to styrene. In n-butyl chloride glass cation radicals of styrene were formed by the transfer of positive charges. The ESR spectrum of the anion radicals is a broad singlet with a width between the maximum slope points of 15 Gs, and bleached readily by visible light, whereas that of the cation radicals has a width of 23 Gs and is not bleached. Radioinduced polymerization proceeded in the glass where the cation radicals were present. Otherwise, no polymerization was found. This suggests that the radioinduced polymerization of styrene, especially in the glassy state, proceeds by a cationic mechanism. (auth) (UK)

**19761** EVIDENCE FOR THE PARTICIPATION OF OXYGEN ATOMS IN $CO_2$ FORMATION DURING GAMMA RADIOLYSIS OF CARBON MONOXIDE GAS. Briggs, J. P.; Clay, P. G. (Imperial Coll. of Science and Tech., London). Int. J. Radiat. Phys. Chem., 1: 67-75(Jan. 1969).

The formation of $O(^3P)$ atoms during gamma radiolysis of carbon monoxide gas was demonstrated using propene and acetylene as scavengers. During radiolysis of carbon monoxide–propene mixtures, products characteristic of reaction of $O(^3P)$ atoms with propene, i.e., propene oxide and propanal were formed in approximately the same yield. Addition of $C_2H_2$ to a $CO/C_3H_6$ mixture resulted in a reduction in the formation rates of propene oxide and propanal to an extent that is proportional to the rate constant ratio for reaction of $O(^3P)$ with $C_3H_6$ and $C_2H_2$. The ratio of rate constants at 22°C ($k_5/k_4$) for the reactions, $O(^3P) + C_3H_6 \xrightarrow{k_4}$ propanal and propene oxide and $O(^3P) + C_2H_2 \xrightarrow{k_5}$ products, calculated from the present work was about 0.063 compared with a value of 0.050 ± 0.009, which may be obtained from the literature. 1-Propanol and 2-propanol were found to be major products of the radiolysis of carbon monoxide/propane mixtures. The alcohol yield ratio and the pressure dependence of the total alcohol yield were not, however, in agreement with the previously reported work on the reaction of $O(^1D)$ with propane. At −183°C the overall reaction stoichiometry was found to be identical to that at 22°C. $G(CO_2)$ at −183°C was found to be about 0.7 molecules per 100 eV and independent of dose rate in the range $2.08 \times 10^{11}$ to $2.56 \times 10^{13}$ eV $cm^{-3}$ $s^{-1}$. It was concluded that: $G(O(^3P)) = 1.41 \pm 0.22$ molecules per 100 eV and that $O(^3P)$ atoms account for about 75 percent of $G(CO_2)$ and that ionic reactions are not involved in $O(^3P)$ atom formation. The experiments described do not preclude the possibility that $O(^1D)$ atoms are the precursors of $O(^3P)$ atoms during gamma radiolysis of carbon monoxide. (auth) (UK)

**19762** FREE RADICAL REACTIONS IN CYCLOHEXANE IRRADIATED AT 77°K. Kabi, A.; Lenherr, A. D.; Ormerod, M. G.; Charlesby, A. (Royal Military Coll. of Science, Shrivenham, Eng.). Int. J. Radiat. Phys. Chem., 1: 45-51(Jan. 1969).

The radical yield of cyclohexane, γ-irradiated at 77°K, was compared with the radiation chemical yields of the major products, dimer and trans-vinylene unsaturation. It was found that the radical-dose curve was not linear and consisted of a low dose linear region partially saturating to give a high dose linear region. The dimer-dose curve was found to follow the radical curve with the yield approximately half the radical yield over the whole dose range used, whereas the unsaturation-dose curve remained linear over the dose range employed. The implications of these results are discussed. (auth) (UK)

**19763** METHOD FOR PRODUCING SHOCK-RESISTANCE POLYPROPYLENE MOLDS. Sugimoto, Kenichi (to Kurashiki Rayon Co., Ltd.). Japanese Patent 1968-26303. Nov. 12, 1968. Filed June 2, 1965.

Polypropylene molds having high shock-strength, especially at low temperatures are produced by irradiating either powder or grains of polypropylene, and bringing the irradiated polypropylene into contact with a diene compound or with an acrylate to yield a graft polymer that is kneadable and can be molded into the desired shapes. (NSA of Japan)

**19764** CONTINUOUS GRAFT-POLYMERIZATION METHOD. Tada, Shotaro (to Sumitomo Electric Industry, Ltd.). Japanese Patent 1968-25976. Nov. 8, 1968. Filed Aug. 8, 1964.

A continuous process for graph polymerization of two sheets of material is proposed. The two sheets, one to which a compound is to be graft polymerized and a second into which the compound has infiltrated, are heated and pressed together. Prior to the pressing operation the film material is irradiated. (NSA of Japan)

**19765** METHOD FOR PRODUCING A GRAFT COPOLYMER. Hirota, Kozo (to Japan Atomic Energy Research Inst.). Japanese Patent 1968-25508. Nov. 4, 1968. Filed Feb. 27, 1961.

A method is proposed for producing a graft copolymer by thinly applying an adhesive material that is unaffected by neutron irradiation on the surface of a sheet of a high-polymer material. Then, a compound containing $^{10}B$ or $^6Li$ is applied over the adhesive film. The whole sample is then irradiated with neutrons in a nuclear reactor. The α particles emitted from the compound in the (n,α) reaction irradiate the compound itself to produce the active radicals on the surface. Thus a vinyl monomer is graft-copolymerized to the polymer. (NSA of Japan)

**19766** METHOD FOR PRODUCING STRENGTHENED PAPER. Asai, Takuo (to Osaka Prefecture). Japanese Patent 1968-27534. Nov. 27, 1968. Filed Mar. 4, 1966.

A method for producing strengthened paper consists of irradiating the pulp while it is soaking in water or a solution of a bleaching agent prior to manufacture of the pulp into paper. (NSA of Japan)

**19767** IDENTIFICATION OF ESSENTIAL RESIDUES IN LYSOZYME: A PULSE RADIOLYSIS METHOD. Aldrich, J. E. (Univ. of Nottingham, Eng.); Cundall, R. B.; Adams, G. E.; Wilson, R. L. Nature (London), 221: 1049-50(Mar. 15, 1969).

The technique of pulse radiolysis was applied to a study of the irradiation inactivation of the enzyme lysozyme, and a method was devised for identifying some of the amino acid residues associated with the enzymatic activity of this substance. The results indicated that specific free radical attack at a tryptophan residue destroys the activity, consistent with crystallographic evidence for the crucial role of tryptophan at the active site. It was concluded that at least 90% of the inactivation observed in neutral aqueous solution is attributable to OH attack on the enzyme. Some OH radical scavengers, such as citrate and ethanol, were found to protect against inactivation; this also applied to t-butanol. After pulse radiolysis of lysozyme a transient spectrum was produced by OH attack, attributed to the lysozyme free radical. On the other hand, it was found that $CNS^-$, which is a very efficient OH radical scavenger, had no effect on the radiation induced inactivation. This suggested that the thiocyanate radical, which is the product of this scavenger reaction, can inactivate the enzyme to the same extent as the OH radical it replaces. The reaction of CNS with lysozyme was followed directly using the pulse radiolysis technique, and the results showed that reaction, which is very fast, occurred exclusively at a tryptophan residue. There were indications in the studies that other radicals are specific for certain amino acids, for example $Br_2^-$ for both tryptophan and histidine, and the carbonate radical for histidine. (UK)

**19768** THE RADIATION CHEMISTRY OF ALCOHOLS. V. METHANE FORMATION IN THE γ-RADIOLYSIS OF HEPTA-DEUTERO-ISOPROPANOL. von Sonntag, C.; Bruening, W. (Kernforschungszentrum, Karlsruhe, Ger.). Int. J. Radiat. Phys. Chem., 1: 25-32(Jan. 1969). (In German).

The formation of $CD_4$ and $CD_3H$ in the γ-radiolysis of hepta-deutero-isopropanol-(OH) was studied in mixtures with 2-deutero-isopropanol and isopropanol. The precursors of the methane formed are mainly "thermal" and "hot" methyl radicals. Molecular elimination processes play a minor role. "Thermal" methyl radicals abstract hydrogen, calculated per C–D bond, 240 times easier from the C–2–D-group than from the $CD_3$-groups of the hepta-deutero-isopropanol. "Hot" methyl radicals have a reduced selectivity, the ratio being 11. The H/D isotopic effect for the hydrogen abstraction reaction of "thermal" methyl radicals was calculated to be 8. (auth) (UK)

**19769** RECOVERY OF NEPTUNIUM, AMERICIUM, AND CURIUM BY IRRADIATION OF NUCLEAR FUELS. Koch, G. (Kernforschungszentrum, Karlsruhe, Ger.). Atompraxis, 15: 26-7(Jan.-Feb. 1969). (In German).

Isotopes of neptunium, americium, and curium are formed as by-products during the irradiation of nuclear fuels in power reactors. The recovery of these isotopes may become economically interesting. During fuel reprocessing by aqueous processes, americium, and curium get into the high-level waste, while neptunium, depending on the processing conditions, is either coextracted or is likewise sent to the high-level waste. A short review is presented on recovery processes for these actinides. (auth)

**19770** PRODUCTION OF $^{51}Cr$ BY THE SZILARD–CHALMERS PROCESS, APPLYING THE OXIDATION-LEACHING METHOD. Shibata, N.; Amano, H.; Yoshihara, K.; Ebihara, H. (Japan Atomic Energy Research Inst., Tokai). Atompraxis, 15: 43-7(Jan.-Feb. 1969).

From neutron-irradiated potassium chromate, $^{51}Cr$ of high specific activity was produced in a scale of 100 mCi per batch by application of an "oxidation-leaching" method to chromic species coprecipitated with lanthanum hydroxide. The method consists of oxidation of the chromic species in lanthanum hydroxide, and of leaching the oxidized species in the precipitate in an alkaline solution. Radioactive chromium can be recovered

as chromate almost quantitatively. Oxidation conditions and a suitable quantity of a lanthanum carrier to be added were determined. This method gave satisfactorily reproducible results for the indicated irradiation conditions in a nuclear reactor. (auth)

**19771** PRODUCTION OF TRANSPLUTONIUM ELEMENTS FROM IRRADIATED $^{241}Am$. Mueller, W. (EURATOM, Karlsruhe, Ger.). Atompraxis, 15: 35-7(Jan.-Feb. 1969). (In German).

The processing of irradiated americium targets involves the separation of an americium–curium mixture from inert cladding and matrix material and from fission products and transuranium elements. Radiolysis and $\alpha$-decay heat of curium affect the separation procedures. Results of an anion exchange-based processing of americium targets, which had been exposed to different integrated neutron fluxes, are summarized. (auth)

**19772** THEORY OF RADIATION CHEMISTRY. IX. MODEL AND STRUCTURE OF HEAVY PARTICLE TRACKS IN WATER. Mozumder, A.; Chatterjee, A.; Magee, J. L. (Univ. of Notre Dame, Ind.). Advan. Chem. Ser., No. 81, 27-48(1968). (COO-38-574).

The structure of heavy particle tracks in water is described with special reference to the highly charged ions of carbon through neon. Range, effective charge, and contribution of charge changing processes to total energy loss were computed as a function of particle energy and quality using a Monte Carlo procedure. Bohr's formulas were used for electron capture and loss with slight modifications to adapt to the present case. A model of heavy particle tracks was proposed for use in radiation chemistry. This consists of a core of high ionization density surrounded by emergent secondary electrons of lower ionization density. Extension of the present model to protons, $\alpha$ particles, and fission fragments is briefly considered. (auth)

**19773** METHOD FOR PRODUCING CONTINUOUSLY A GRAFT POLYMER. Araki, Kunio (to Japan Atomic Energy Research Inst.). Japanese Patent 1968-27114. Nov. 21, 1968. Filed Oct. 24, 1966.

In a method for continuously producing a graft-polymer, a gaseous monomer capable of polymerization is brought in contact with an organic polymer in the form of grains or powder with the two flowing either in the same direction or in opposite directions. While in contact, the two are irradiated with an ionizing radiation. (NSA of Japan)

**19774** ELECTRON SPIN RESONANCE STUDY OF $\gamma$-IRRADIATED CARBOHYDRATE ICES AT LOW TEMPERATURES. Baugh P. J.; Kershaw, K.; Phillips, G. O. (Univ. of Salford, Eng.). Nature (London), 221: 1138-9(Mar. 22, 1969).

Difficulties encountered in previous studies on the structure of free radical species induced in $\gamma$-irradiated carbohydrates are briefly discussed. As an alternative approach to this problem the radical species induced in aqueous carbohydrate ices $\gamma$ irradiated at −196°C were examined, and ESR spectroscopy was used to study exchanges occurring on warming. Samples of d-glucose and sucrose were $\gamma$ irradiated at −196°C using a 10,000 Ci $^{60}Co$ source at a dose rate of $4.5 \times 10^{17}$ eV/g/min. It was found that the ESR spectra of these two sugars at −196°C were very similar. The effects of photobleaching and heat on the spectra are discussed. At −80°C both sugars showed five line spectra with almost identical hyperfine splittings and relative intensities. A composite spectrum consisting of a 1 : 1 doublet and 1 : 2 : 1 triplet could be assigned to the radicals in both ices. It is believed that the triplet arises from radicals of the type $\dot{C}-CH_2OH$, with free rotation of the two equivalent protons about the $C_3-C_\beta$ bond. The doublet is probably the result of the formation of a radical by abstraction of a proton from the $C_1$ position. (UK)

**19775** PURIFYING RADIOACTIVE ISOTOPES. (to Sanders Nuclear Corp.). British Patent 1,144,415. Mar. 5, 1969. Priority date Dec. 2, 1966, United States.

A method is described for purifying a radioisotope of a material that can be neutron activated to a first isotope that in turn can be neutron activated to a second isotope. The material to be irradiated is combined with an organic carrier to form a stable compound useful as target material. This target material is irradiated for a period of time at a neutron flux sufficient to form a first isotope, and the recoil energy in the compound after irradiation is allowed to free the first isotope from the carrier. The first isotope is combined with an organic carrier to form a second organic compound that is irradiated to form the second isotope, which is separated from the carrier by the recoil energy so that it can be separated from the reaction mixture and products remaining after irradiation. The method is applicable to the production of $^{169}Tm$ and $^{171}Tm$. (B.L.M.)

**19776** INVESTIGATIONS IN THE FIELD OF RADIATION-INDUCED SOLID STATE POLYMERIZATION. XXV. INFLUENCE OF A SECOND COMPONENT ON THE SOLID STATE POLYMERIZATION OF CETYL VINYL ETHER. Hardy, Gyula; Nyitrai, Karoly; Cser, Ferenc (Muanyagipari Kutato Intezet, Budapest). Magy. Kem. Foly., 74: 608-11(Dec. 1968). (In Hungarian).

The polymerization kinetical behavior of the binary systems cetyl vinyl ether–p-benzoquinone and cetyl vinyl ether–dimethyl oxalate was investigated in the solid state. On the basis of the results, it can be established that these additives slightly retard the polymerization up to the eutectic ratio, but their effect is unchanged at higher ratios. Consequently, their role can only be explained by physical factors. The solid phase polymerization of cetyl vinyl ether has a cationic mechanism, and it is proved, by the possibility of iodine vapor-initiated solid phase polymerization. (auth)

**19777** PULSE RADIOLYSIS OF p-NITROSODIMETHYLANILINE IN AQUEOUS SOLUTION. Baxendale, J. H.; Khan, A. A. (Univ. of Manchester, Eng.). Int. J. Radiat. Phys. Chem., 1: 11-24(Jan. 1969).

In neutral solution, p-nitrosodimethylaniline (RNO) reacts with OH radicals to give $RNO_2H$ (or $RNO_2^-$), and with H, $e_{aq}^-$ and some organic radicals to give RNOH (or $RNO^-$). These transient species decay mainly by dismutation to regenerate RNO and give the products $RNO_2$ and RNHOH. Rate constants for the OH and organic radical reactions were obtained and the primary radical yields were calculated from the consumption of RNO under various conditions. Absolute rate constants for OH reactions with hydrogen peroxide, methanol, ethanol, i-propanol and formate ion were measured using competition kinetics and $k = 1.25 \times 10^{10}$ $M^{-1}$ $s^{-1}$ for the OH + RNO reaction. Absolute rate constants for the reaction of oxygen with the radicals $CH_3\dot{C}HOH$, $(CH_3)_2\dot{C}OH$ and $CO_2^-$ were also obtained. (auth) (UK)

**19778** IRRADIATION OF ALKALI METAL AZIDES. Papazian, Harold A. (Martin Marietta Corp., Denver, Colo.). J. Phys. Chem. Solids, 30: 462-3(Feb. 1969).

It has been shown by a vibrational frequency calculation and group theoretical considerations that upon irradiation of $NaN_3$ at low temperature some of the normally linear $D_{\infty h}$ azide ions of the crystal assume the equilateral triangle $D_{3h}$ symmetry. It is of considerable interest to consider the consequences of this symmetry and to note how it may be used to explain the observations. Thus the experimental observation of one new electronic band and one new infrared band can be explained by the $D_{3h}$ symmetry for the azide ion as the "color center." The experimental observations during warmup may be accounted for by assuming a slight distortion in the $D_{3h}$ ion. (UK)

**19779** RADIATION CHEMISTRY OF AQUEOUS SOLUTIONS OF SODIUM NITROPRUSSIDE. Buxton, G. V.; Dainton, F. S.; Kalecinski, J. (Univ. of Leeds, Eng.). Int. J. Radiat. Phys. Chem., 1: 87-98(Apr. 1969).

The radiation chemistry of aqueous solutions of nitroprusside was studied by pulse and steady-state methods. The data show that nitroprusside is reduced by $e_{aq}^-$, H, and $CO_2^-$, and oxidized by OH, and therefore, contrary to a previous proposal, it is not a specific reagent for excited water molecules. Relevant rate constants are: $k(e_{aq}^- + Fe(CN)_5NO^{2-}) = 2.2 \times 10^{10}$ l $mol^{-1}$ $s^{-1}$; $k(CO_2^- + Fe(CN)_5NO^{2-}) = 3.7 \times 10^8$ l $mol^{-1}$ $s^{-1}$; and, $k(OH + Fe(CN)_5NO^{2-}) = 1.2 \times 10^7$ l $mol^{-1}$ $s^{-1}$. The photodecomposition of nitroprusside at $\lambda > 300$ nm proceeds by two mechanisms: $Fe(CN)_5NO^{2-} + h\nu \rightarrow Fe(CN)_5^{3-} + NO$ and $Fe(CN)_5NO^{2-} + h\nu \rightarrow Fe(CN)_5NO^- + e_{aq}^-$. (auth) (UK)

**19780** FORMATION OF MOLECULAR HYDROGEN BY $\gamma$-IRRADIATION OF AQUEOUS SOLUTIONS OF SODIUM BENZENESULPHONATE. Faraggi, M.; Desalos, J. (CEN, Saclay, France). Int. J. Radiat. Phys. Chem., 1: 263-6(Apr. 1969). (In French).

Yields of molecular hydrogen in the presence of sodium benzenesulfonate (S) at different concentrations were measured and interpreted on the basis of a reaction of hydride ions with the solute, $H^- + S \rightarrow H_2$, which competes with the process, $H^- + H_2O \rightarrow H_2 + OH^-$. The latter process is considered as the probable source for most of the molecular hydrogen. (auth) (UK)

**19781** RADIOLYSIS OF CYCLIC FLUOROCARBONS. II. PERFLUOROAROMATICS AT ELEVATED TEMPERATURES. Bloch, F. W.; MacKenzie, D. R. (Brookhaven National Lab., Upton, N. Y.). J. Phys. Chem., 73: 552-7(Mar. 1969).

Aromatic fluorocarbons are known to have high thermal stability but only moderate stability to radiation at or slightly above room temperature. In this study of perfluorobenzene, perfluoronaphthalene, perfluorobiphenyl, and perfluoro-o-terphenyl, mod-

erate radiation stability was maintained at elevated temperatures where most organic compounds undergo rapid decomposition by heat alone. For example, perfluorobiphenyl at 500° is several orders of magnitude more stable thermally and many times more stable to γ radiation than are the hydrocarbons biphenyl and o-terphenyl. At 100° polymerization is almost the only process occurring and G values range from 1.5 to 3. At 450° it is still the most important process, with G values from 2 to 6, but formation of $F_2$-addition products has become appreciable. Fragmentation is insignificant. Although the temperature coefficient of overall radiolytic decomposition is small, quite large changes occur in the product distributions in going from 100 to 450°. This is particularly apparent in the case of $C_6F_6$ where products have been characterized to the greatest extent. The implications regarding mechanism and changes in mechanism with temperature are discussed. (auth)

**19782** FERROELECTRIC EFFECTS IN IRRADIATED $(NH_4)_2SO_4$ AND $(ND_4)_2SO_4$. Barbur, I. Stud. Univ. Babes-Bolyai, Ser. Math.-Phys., No. 2, 139-41(1968). (In Rumanian).

Two paramagnetic species appeared in γ-irradiated single crystals of $(NH_4)_2SO_4$ and $(ND_4)_2SO_4$. These species were free radicals. Using the ESR method the radical resulted from the ammonium group in the region of ferroelectric transition temperature of ammonium sulfate was studied. The constant of the hyperfine interaction of the unpaired electron with the nitrogen nucleus changed with temperature and reached a maximum at the transition temperature. The same effect has been observed for the $(ND_4)_2SO_4$ sample. Some comments on the nature of this variation are presented. (auth)

**19783** THE EFFECT OF pH AND SODIUM METABISULFITE ON THE STABILITY OF PHYSOSTIGMINE SULFATE SOLUTIONS TO HEAT AND IONIZING RADIATION. Fletcher, G.; Davies, D. J. G. (Bath Univ. of Tech., Bristol, Eng.). J. Pharm. Pharmacol., 20: Suppl., 108-13(Dec, 1968).

A comparison was made of the influence of pH and sodium metabisulfite on the effects of heat or exposure to $^{60}Co$ γ radiation on the degradation kinetics of aqueous physostigmine systems. A method that assays the alkaloid in the presence of its breakdown products was used. Maximum stability at 90° was between pH 2.2 and 3.0. Sodium metabisulfite retarded the degradation of physostigmine when exposed to γ irradiation, but had no effect on the degradation by heat. The presence of sodium metabisulfite in solutions of physostigmine improved the stability of the alkaloid to doses of 1 to 7 Mrad; 0.5% wt/v solutions were more effective than 0.2% wt/v. Plots of percent residual concentration against irradiation dose and subsequent period of heating and period of heating with no irradiation were superimposable, so that a solution, when stored after irradiation, degraded at the normal rate for the storage temperature. From the amount of degradation resulting from 2.5 Mrad, it was possible to formulate eyedrops to include the required excess of drug. Thus the solutions could be radiosterilized and still contain the full amount of the stated amount of drug in the preparation. The irradiated alkaloid may decompose by 2 possible mechanisms: a direct ionizing effect on the molecule leading to disruption; and an indirect oxidative-chain-reaction effect due to attack of such agents as $OH^{\cdot}$, $HO_2^{\cdot}$, $H^{\cdot}$, and $H_2O$ resulting from the irradiation of water. (BBB)

**19784** NEW FIBER-FORMING POLYAMIDES. Fedotova, O. Ya.; Shtil'man, M. I.; Kolesnikov, G. S. (Moscow Chemical Engineering Inst.). Khim. Volokna, No. 3, 5-7(1968). (In Russian).

Synthesis of polyamides from 6-dodecene-1,12-dicarboxylic acid ($K_{C14}$) and 6,10-hexadecadiene-1,16-dicarboxylic acid ($K_{C18}$) with ethylenediamine (ED), hexamethylenediamine (HMD) and decamethylenediamine (DMD), the fiber forming properties of the polymers, and thermal and mechanical properties of initial and irradiated fibers were studied. The salts of diamines and dicarboxylic acids were heated in an inert gas stream for 5 hours and subsequently under 5 to 7 mm vacuum for 2 hours. Synthesis temperature was 260°C for polyamides from $K_{C14}$ and 180°C for the polymers prepared from $K_{C18}$. The fibers were irradiated with gamma radiation from a $^{60}Co$ source at 2.7 MRAD/hr, and were studied by determination of thermomechanical properties on the Zhurkov apparatus and by measuring properties according to GOST. X-ray analysis and melting point measurements were used to define the physical properties. The melting points were 149 to 244°C, and at 250 to 350°C crosslinking occurred, indicated by a marked exothermic effect. Extrusion from the melt produced fibers with 10 to 20 rkm tensile strength. Ultraviolet irradiation did not improve the mechanical properties, but gamma irradiation resulted in increased tensile strength and reduced terminal elongation. The best results were obtained with the polymer prepared from $K_{C14}$ and HMD (PA-14). The strength of irradiated PA-14 markedly exceeded the strength of commercial cord produced from polyhexamethyleneadipamide and polycaproamide irradiated under identical conditions. Irradiation also improved the resistance of PA-14 to 30% KOH, 25% $NH_4OH$, and dimethylformamide, trichloroethylene, chlorobenzene, benzene, methanol, and acetone. Ninety-six percent $H_2SO_4$ caused deformation. (ATD)

**19785** INVESTIGATION OF INTRAMOLECULAR ENERGY TRANSFER IN α, ω-DIPHENYL ALKANES. Kules, Inna; Ero-Gecs, Maria. Acta Chim. Acad. Sci. Hung., 58: 389-97(1968). (In Russian).

The intra- and intermolecular energy transfer was investigated in α,ω-diphenylalkane compounds and in benzene–alkane mixtures. Changes in the length and type of the alkyl chain (normal or iso product), the nature of the chemical bonds, and hydrogen and free radical yields after γ-irradiation were measured. Experimental results showed that in compounds of α,ω-diphenyl alkane type the aromatic group exerts a considerable protecting action on the aliphatic group. The probability of energy transfer was estimated within the molecule and in mixtures of the given proportion of the components. (auth)

**19786** RADIATION-INDUCED CROSSLINKING OF PARAFFINS. Salovey, R.; Hellman, M. Y. (Bell Telephone Labs., Inc., Murray Hill, N. J.). Macromolecules, 1: 456-9(Sept.-Oct. 1968).

Gel permeation chromatography was used for analyzing crosslinked products from the irradiation of long-chain normal paraffins. For irradiated solid and liquid n-pentatriacontane and solid n-hexatriacontane, the G-values of cross-linking at zero dose were 1.4, 1.8, and 1.1, respectively. Gel permeation chromatograms of irradiated liquid n-hexatriacontane indicated an additional, presumably multiply cross-linked, product corresponding to 25% of the total dimer area, regardless of dose. The same product distribution was observed in liquid state radiolyses of n-hexatriacontane purified by the removal of an olefinic impurity on recrystallization. An increase in cross-linking yield with dose observed in irradiated n-$C_{35}$ paraffin was reminiscent of a similar effect inferred from solubility studies on irradiated polyethylene. The marked effect of physical state and crystalline packing on crosslinking yields suggested complex crosslinking in polyethylene with regions of varied order and packing. (BBB)

**19787** γ-RADIOLYSIS OF DISULFIDES IN AQUEOUS SOLUTION. III. L-CYSTEINE-D-PENICILLAMINE MIXED DISULFIDE. Purdie, J. W. (Defence Research Establishment, Ottawa). Can. J. Chem., 47: 1037-43(Mar. 15, 1969).

L-Cysteine-D-penicillamine mixed disulfide (CySSPen) was irradiated in aerated and deaerated aqueous solutions with $^{60}Co$ γ-rays. G values were determined for all products identified after exposure to 10,000 RADs. The major products were the sulfinic and sulfonic acids ($CySO_2H$, $CySO_3H$, and $PenSO_2H$) the sulfhydryl derivatives (CySH and PenSH), symmetrical disulfides (CySSCy and PenSSPen), three trisulfides (CySSSCy, CySSSPen, and PenSSPen), and ammonia. Each half of the disulfide behaved in exactly the same way as the corresponding symmetrical disulfide: products from the CyS—part of the disulfide were dose rate dependent while products from the PenS—part were independent of dose rate. The reactions proposed for the symmetrical disulfides were adequate to explain radiolysis of the unsymmetrical disulfide. Radiolysis of a mixture of cystine and penicillamine disulfide was examined for comparison with the unsymmetrical disulfide and was found to give very similar results. It was concluded that the free radicals produced from the water attack each half at approximately equal rates. (auth) (Canada)

**19788** GERMANIUM ATOMS. REACTIONS WITH GERMANE AND SILANE. Gaspar, Peter P.; Levy, Carl A.; Frost, John J.; Bock, S. Allan (Washington Univ., St. Louis). J. Amer. Chem. Soc., 91: 1573-4(Mar. 12, 1969). (COO-1713-8).

A study of recoiling Ge atoms is reported from irradiation of pure germane and also from irradiation of germane–silane mixture. Germanium atoms were produced from gaseous germane by recoil from the nuclear transformation $^{76}Ge(n,2n)^{75}Ge$. The cross section for the formation of $^{75}Ge$ increased rapidly from the threshold energy of 9.35 Mev to 1.82 barns for 14.5-MeV neutrons. Irradiation of pure germane with fast neutrons produced germane and digermane as the sole volatile radioactive products detected by standard radio-vapor-chromatographic methods. The product ratio $H_3{}^{75}GeGeH_3/{}^{75}GeH_4 = 5.0 \pm 0.8$ is identical within experimental error to the product ratio $H_3{}^{31}SiSiH_3/{}^{31}SiH_4 = 4.8 \pm 0.9$ obtained from the irradiation of silane-rich phosphine–silane mixture. Fast-neutron irradiation of a 1:1 germane–silane mixture produced $H_3{}^{75}GeSiH_3$ as well as $^{75}GeH_4$ and $H_3{}^{75}GeGeH_3$. In a scavenger experiment the yield ratio of $H_3{}^{75}GeGeH_3$ to $^{75}GeH_4$ decreased upon the addition of 10% nitric oxide to germane prior to irradiation. (D.H.M.)

**19789** TEMPERATURE DEPENDENCE OF THE REACTION YIELDS FROM RECOIL TRITIUM REACTIONS. I. ENERGETICS OF TRITIUM ATOM ADDITION TO OLEFINS. Kushner, Richard; Rowland, F. S. (Univ. of California, Irvine). Contract AT(11-1)-34. J. Amer. Chem. Soc., 91: 1539-40(Mar. 12, 1969).

The temperature and pressure effects on the decomposition of excited sec-butyl radicals, as formed by recoil tritium addition to 1-butene or cis-2-butene were investigated. Evaluation of these changes indicates that about three-fourths of such additions to olefins are initiated by tritium atoms with kinetic energies in the range from 3 eV to thermal energies. The relative yields of $CH_3CH=CHT$ and the labeled parent molecule were measured at 24 and 125°C over a range of pressures from 3 to 76 cm. Similar observations were made concerning the terminal addition of T* to 1-butene. The ratio of the yield of propylene-t to that of the labeled parent molecule is higher at the higher temperature by $1.07 \pm 0.02$ at 5 cm and $1.04 \pm 0.01$ at 76 cm for 1-butene experiments, with quite similar results for cis-2-butene. At each temperature the yield of propylene-t varies more than 30% with a 15-fold change in pressure. Addition to the terminal position is favored by a factor of 2 or 3 in the 1-butene system. Addition below 1 eV strongly favors the terminal position, while at higher energy addition proceeds at both positions more or less equally. The temperature effects observed were made entirely in terms of temperature effects on the secondary decomposition reaction, not upon the primary reaction itself. (D.H.M.)

**19790** ESR STUDY OF L-ALANINE-1-$^{13}$C IRRADIATED AT LOW TEMPERATURES. Sinclair, James; Hanna, Melvin W. (Univ. of Colorado, Boulder). J. Chem. Phys., 50: 2125-9 (Mar. 1, 1969).

The ESR spectra of L-alanine-1-$^{13}$C, x irradiated at low temperatures (T < 150°K), have been examined. The spectra have been interpreted in terms of a carboxyl radical similar to those postulated for other irradiated organic acids. From the values of the $^{13}$C hyperfine tensor it has been confirmed that the unpaired electron is essentially a $2p\pi$-type electron located primarily on the carboxyl carbon and that this spin density interacts with the $\alpha$ proton. From the magnitude of the isotropic $^{13}$C hyperfine splitting it was found that the $RCO_2^{\cdot}$ structure is bent about 8° from planarity. The stable room-temperature fragment in irradiated L-alanine-1-$^{13}$C exhibited essentially isotropic $^{13}$C splittings of 12.8 G. (auth)

**19791** BEHAVIOR OF RECOIL RADIOIODINE ATOMS RESULTING FROM HIGH-ENERGY PROTON IRRADIATION OF THE MIXED CRYSTALS OF ALKALI HALIDES. Dema, I. (Inst. of Atomic Physics, Bucharest); Zaitseva, Natalia G. Rev. Roum. Phys., 13: 857-68(Oct. 1968).

A study of the chemical distribution of radioiodine between its higher ($IO_4^-$, $IO_3^-$) and lower ($I^-$, $I_2$, $IO^-$) oxidation states produced by spallation reactions in cesium inorganic solids such as CsCl, CsBr, CsCl–CsBr, CsCl–NaCl, CsCl–KCl, and CsCl–RbCl mixed crystals showed an increase of the higher valency radioiodine yield in some mixed crystals as compared with pure salts (CsCl or CsBr). Thermal annealing of the bombarded crystals indicates the existence of oxidation–reduction reactions of recoil atoms. The observed phenomena was explained from the point of view of defect centers induced by irradiation in the crystals. (auth)

**19792** EFFECT OF WATER ON THE RADIOLYSIS OF LIQUID ACETONE. Barker, R.; Noble, C. M. (United Kingdom Atomic Energy Authority, Wantage, Eng.). J. Chem. Soc., A, No. 4, 717-19(1969).

Small concentrations (up to 0.4 vol %) of water greatly affect the radiolysis of liquid acetone; the yields of hydrogen, methane, and hexane-2,5-dione are increased and the yields of ethyl methyl ketone and 4-hydroxy-4-methylpentan-2-one are decreased. These effects are interpreted in terms of ionic reactions, for which there exists evidence from ion–molecule studies and from spectroscopic work with low temperature glasses. Liquid acetone is quickly and efficiently dried with a 4 Å molecular sieve. (auth) (UK)

**19793** EFFECT OF VARIATION IN PORE SIZE ON THE RATE OF RADIOLYTIC CORROSION OF GRAPHITE BY CARBON DIOXIDE. Labaton, V. Y. (United Kingdom Atomic Energy Authority, Culcheth, Eng.); Ashton, B. W.; Lind, R.; Tait, J. N. Carbon, 7: 59-75(Feb. 1969).

The effect of variation in pore size on the rate of radiolytic oxidation of graphite by $CO_2$ was investigated by oxidation in the DIDO materials testing reactor of "A" grade graphite to higher weight losses than previously (final open pore volume (OPV) 35 cm$^3$/100 g at a weight loss of 28%), and also of a range of graphites with varying pore dimensions and open porosity. It was shown that if a substantial proportion of the open pores are larger than a critical size, which is dependent on the gas pressure, the oxidation is less than that predicted from its OPV; the results were assessed in terms of active species of a definite range and alternatively in terms of the survival probability of specimens which react strongly with CO. (auth) (UK)

**19794** EVIDENCE FOR THE PRODUCTION OF AN OXIDIZING RADICAL ON PULSE RADIOLYSIS OF METHANOL. Dainton, F. S.; Janovsky, I. V.; Salmon, G. A. (Univ. of Leeds, Eng.). J. Chem. Soc., D, No. 7, 335-6(Apr. 9, 1969).

It is stated that hitherto the radiation chemistry of alcohols has been explained exclusively in terms of reducing species ($e_s^-$, H·, and RCHOH). Data are now reported, however, that prove that an oxidizing species (probably MeO·) is formed during the radiolysis of deaerated methanol. Solutions of KI or $NH_4SCN$ in dry methanol were irradiated with 0.6 μsec pulses of 3 MeV electrons and kinetic absorption spectroscopy was applied for the detection of transient species. Two peaks were observed for the iodide solution, decaying at different rates. The peak with $\lambda_{max}$ 630 nm was assignable to the solvated electron; the second peak at $\lambda_{max}$ 380 nm correlated well with the absorption spectrum of the $I_2^-$ radical ion. A peak at 470 nm in the thiocyanate solutions was identifiable with the analogous $(SCN)_2^-$ radical ion. These species are attributed to the reaction of $I^-$ or $SCN^-$ ions with the products formed by the oxidation of $I^-$ or $SCN^-$ by an oxidant generated by irradiation of the methanol. This oxidant is probably MeO·, which is formed together with $\cdot CH_2OH$ radicals. Reaction schemes are presented. In the absence of a sufficient concentration of an oxidizable solute the MeO· radicals are converted into the thermodynamically more stable $\cdot CH_2OH$ radicals by a H-atom abstraction reaction. (UK)

**19795** MACROMOLECULAR STRUCTURAL STUDIES OF IRRADIATED AND GRAFTED POLYSTERS. DasGupta, Sharda (Atomic Energy of Canada Ltd., Ottawa). Can. Spectrosc., 14: 48-51(Mar. 1969).

Polyethylene terephthalate (PET) in the form of films, fibers, or as fabrics when subjected to gamma radiation from $^{60}$Co showed various changes in properties and in the macromolecular structure. Infrared spectral studies revealed that crosslinking occurs until a radiation dose of 50 megarads is given, after which degradation predominates. Radioinduced grafting of styrene and acrylamide onto PET under controlled conditions resulted in the formation of graft co- and terpolymers. These products have remarkable properties of commercial interest. Probable mechanisms involved during synthesis are discussed. (auth) (Canada)

**19796** RADIOLYSIS OF AQUEOUS BENZENE SOLUTIONS. EFFECT OF NITROUS OXIDE AND IRON IONS. Christensen, H. B.; Gustafsson, R. (Aktiebolaget Atomenergi, Studsvik, Sweden). Nukleonik, 12: 49-53(Jan. 1969).

Aqueous solutions of benzene were irradiated in the absence of oxygen with $^{60}$Co γ rays in doses from 3,000 to 210,000 RAD. In solutions saturated with argon the G values of phenol, biphenyl, and hydrogen peroxide were 0.31, 0.9, and 0, respectively. In solutions containing about $2 \times 10^{-2}$ M nitrous oxide the corresponding yields were 0.79, 3.0, and 0.57. Smaller changes in the yields were noted when the solutions were made $10^{-3}$ N acid, e.g., the expected increase to 0.51 in the hydrogen peroxide yield in argon saturated solutions. In solutions containing Fe(II) ions the yield of hydrogen peroxide was reduced to zero in all cases, whereas the yields of phenol and biphenyl were changed but little when the Fe(II) was added in concentrations small enough to avoid direct competition for OH radicals. Addition of $10^{-2}$ M Fe(III) ions caused an increase of the phenol yield by one order of magnitude and a simultaneous decrease of the biphenyl yield. Reaction mechanisms are discussed. The rate constant for the reaction between Fe(III) ions and $C_6H_6OH\cdot$ radicals was estimated at $7 \times 10^3$ $M^{-1}$ $s^{-1}$. (auth)

**19797** HOT ATOM CHEMISTRY OF TRIPOLYPHOSPHATE. II. REACTIONS OF $^{32}$P RESULTING FROM NEUTRON ACTIVATION. Matsuura, Niro; Shinohara, Nobuyoshi; Lin, Tsing-ko (Tokyo Univ.). J. Inorg. Nucl. Chem., 31: 1251-61(May 1969).

Sodium tripolyphosphate hexahydrate ($Na_5P_3O_{10} \cdot 6H_2O$) and the anhydrous salt ($Na_5P_3O_{10}$) were irradiated at reactor temperature of about 60°C, dry-ice temperature of about −76°C, in the liquid state (aqueous solution) and in the frozen state. The retention increased with increases of irradiation time at reactor temperature from 30 to 50%, but at dry-ice temperature a constant but lower retention value of about 28% was obtained. Water molecules, either as water of hydration or solvent, play a very important role in the chemistry of the recoil species. The retention value was largely reduced by the presence of water molecules. Under the same experimental conditions the retention value of the anhydrous salt attained 48%, while hexahydrate salt was 38%, frozen state (0.1 M aqueous solution) was 8.5%, and liquid state (0.1 M aqueous solu-

tion) was 1.0%. The labeling position of $^{32}P$ in tripolyphosphate was determined by the limiting alkaline hydrolysis method and the radioactivity was found uniformly distributed among the three phosphorus atoms. Sodium pyrophosphates ($Na_4P_2O_7 \cdot 10\ H_2O$ and $Na_4P_2O_7$) and sodium polymetaphosphate ($NaPO_3$) were irradiated in the same way as in tripolyphosphate and a similar trend of results was obtained. (auth) (UK)

**19798** NOTE ON THE PAPER "LOW-DOSE X-RADIOLYSIS OF CYSTINE." Brdicka, R.; Fojtik, A. (Inst. of Physical Chemistry, Prague). Collect. Czech. Chem. Commun., 34: 670-2 (Feb. 1969).

It is shown that data characterizing the radiation yields related to the consumption of disulfide groups in cystine, as detailed by Owen et al. (J. Am. Chem. Soc., 90: 196(1968)), are in fair agreement with those obtained in studies under comparable conditions. (M.C.G.)

**19799** SOME REMARKS ON THE FRAGMENTATION OF EXCITED IONS IN THE RADIOLYSIS OF HYDROCARBONS. Miyazaki, Tetsuo (Nagoya Univ., Japan); Tanno, Kuniyasu; Shida, Shoji. Bull. Chem. Soc. Jap., 42: 362-5(Feb. 1969).

The fragmentation of excited ions in the liquid-phase radiolysis of hydrocarbons is explained by a mechanism that involves the fragmentation of a highly excited ion ($M^{+**}$). The $M^{+**}$ ion is considered to have electronic excited states. The electronic excitation energy can spread over all C–C bonds in a molecule before its fragmentation and, when the mean excitation energy per C–C bond exceeds its bond energy, the excited ion decomposes instantaneously in one vibration. The mass spectra of isobutane and isooctane were calculated by a simplified quasi-equilibrium theory by introducing the highly excited ion and compared with experimental mass spectra with the calculated values without introducing the highly excited ion. (auth)

**19800** OPTICAL AND THERMAL CONVERSION OF $V_k$ CENTERS IN X-IRRADIATED HYDROXYLAMMONIUM CHLORIDE. Ohigashi, Hiroji; Kurita, Yukio (Toyo Rayon Co., Ltd., Tebiro, Japan). J. Phys. Soc. Jap., 26: 769-72(Mar. 1969).

The $Cl_2^-$ centers trapped in x-irradiated single crystals of hydroxylammonium chloride have been studied by electron spin resonance technique in the temperature range from 77 to 150°K. Two crystallographically inequivalent $Cl_2^-$ centers designated as $V_k(I)$ and $V_k(II)$ were produced in the crystal. The former was composed of a chlorine ion pair situated on the bc plane and the latter was formed from a pair on the plane nearly perpendicular to the bc plane. Thermal conversion from $V_k(I)$ into $V_k(II)$ took place thermally above 105°K and $V_k(II)$ was converted into $V_k(I)$ by irradiation with the $V_k$ light at 77°K. (auth)

**19801** SOME COMMENTS AND CALCULATIONS ON THE RADIOLYTIC DECOMPOSITION OF DILUTE HYDROGEN PEROXIDE SOLUTIONS AND THE VALUE OF $g_{e_{aq}^-}$. Hickel, Bernard; Sutton, Jack (CEN, Saclay, France). Int. J. Radiat. Phys. Chem., 1: 177-83(Apr. 1969). (In French).

Extensive machine calculations were carried out on data concerning the radiolytic decomposition of dilute hydrogen peroxide solutions. It was shown that results of both Czapski and Allen (J. Phys. Chem., 66: 262(1962)) and Hayon (Trans. Faraday Soc., 60: 1059(1964)) support the value $g_{e_{aq}^-} = 2.3$ if the rate constant ratio $k(e_{aq}^- + O_2)/k(e_{aq}^- + H_2O_2) = 1.53$. Accepting this value of $g_{e_{aq}^-}$ makes unnecessary the assumption of a small yield of a second oxidizing species. Furthermore, using these two values, Hayon's experimental results can be reproduced over the entire dose range employed, thus eliminating the need to postulate a change of mechanism for the disappearance of the hydrogen atom precursor. (auth) (UK)

**19802** RADIOLYTIC YIELD OF REDUCING RADICALS IN NEUTRAL AQUEOUS SOLUTION. Bielski, B. H. J.; Allen, A. O. (Brookhaven National Lab., Upton, N. Y.). Int. J. Radiat. Phys. Chem., 1: 153-63(Apr. 1969).

By use of the ultrasensitive Cary Model 16 spectrophotometer, accurate initial γ-ray yield values were obtained at doses of only 30 to 150 RAD for the oxidation of ferrous sulfate in air-saturated solutions at low acidities, and for peroxide formation in air-saturated solutions of ethanol and of sodium formate. The yields were in most cases higher than those previously reported, and led to values of $G_{red} = 3.31 \pm 0.05$ for the yield of total reducing radicals and $G_{OH} = 2.74 \pm 0.08$ for oxidizing radicals in neutral solutions. The results tend to confirm values of the radical yields reported by M. Haissinsky. (auth) (UK)

**19803** THEORY OF RADIATION CHEMICAL YIELD. V. INITIAL STRUCTURE OF THE TRACK OF A FAST ELECTRON IN A DENSE MEDIUM. Santar, I.; Bednar, J. (Inst. of Nuclear Research, Rez, Czech.). Int. J. Radiat. Phys. Chem., 1: 133-52 (Apr. 1969).

The correspondence is discussed between the statistical descriptions of primary radiation-chemical processes by means of the electron degradation spectra and by models of the average track of a fast electron in a dense medium. It is shown that the model of the track composed of spurs, blobs, and short tracks can be formulated on two levels. The gross structure of the track (the original model developed by Magee and Mozumder) comprises the formation of blobs and short tracks in the first generation of hard collisions in the track. The detailed structure of the track corresponds to the complete statistical picture of the degradation spectrum which includes all generations of δ-electrons. The molecular nature of condensed media is shown to affect only the numbers and the distribution of spurs generated in optical collisions of fast electrons in the track. In this respect the so-called optical approximation provides a promising approach to the study of track effects in liquids. On the other hand, the basic skeleton of the track composed of the main track together with branch tracks, short tracks, and blobs is essentially invariable in all liquids composed of light elements. The results of calculations of the initial track structure for a 1 MeV electron in water and in a hydrocarbon medium are presented as illustrative examples. (auth) (UK)

**19804** THE $^{60}Co$ GAMMA-RADIOLYSIS OF REDUCED GLUTATHIONE IN DEAERATED AQUEOUS SOLUTIONS. Lal, Manohar; Armstrong, D. A.; Wieser, Meta (Univ. of Calgary, Alberta, Can.). Radiat. Res., 37: 246-52(Feb. 1969).

The major products of radiolysis of air-free aqueous solutions of the tripeptide glutathione were hydrogen, hydrogen sulfide, oxidized glutathione, and γ-glutamylalanylglycine. The last of these resulted from the replacement of SH by H. There was no evidence for scission of the peptide chain, and the pH dependence and magnitudes of the product yields closely resembled those of the analogous products from cysteine solutions. The radiolytic mechanism was found to be similar to that for cysteine. (auth)

**19805** THE RADIOLYSIS OF ALCOHOLS AT LOW TEMPERATURES. I. THE PRECURSORS OF HYDROGEN IN GLASSY METHANOL. Teply, Jiri; Janovsky, Igor (Inst. of Nuclear Research, Prague). Int. J. Radiat. Phys. Chem., 1: 119-31(Apr. 1969).

Using various electron and hydrogen atom scavengers the γ-irradiation yields of different hydrogen precursors in glassy photobleached methanol were determined; the yields of the trapped electrons, of the independently formed hydrogen atoms, of the hot hydrogen atoms and of the "molecularly" formed hydrogen were found to be 2.3, about 0.5, about 1.1 and about 0.3, respectively. Some conclusions about the separation of electrons from their conjugated ions are drawn from a comparison of these yields with those for liquid methanol. In acid methanol glass $G(H_2)$ was larger by 0.5 than in neutral glass. A possible explanation is that a low excited state of methanol is decomposed by the influence of the electric field of the ions. When the irradiated methanol glass was warmed in the dark (thermally bleached) the yields of hydrogen and glycol were smaller, but the reasons for this are not clear. The crystalline methanol also gives questionable results. A few remarks on the process of electron trapping are made. (auth)

**19806** PULSE RADIOLYSIS STUDY OF SILVER CHLORIDE FORMATION AND PRECIPITATION. Schiller, R.; Ebert, M. (Christie Hospital and Holt Radium Inst., Manchester, Eng.). Int. J. Radiat. Phys. Chem., 1: 111-18(Apr. 1969).

Stable ions were formed by a 1-μs pulse of high-energy electrons, and the reactions and precipitate formation of these ions were followed. The formation kinetics of the $AgCl_2^-$ complex were studied by irradiating aqueous chloroacetic acid plus silver acetate solutions of appropriate concentrations. The observations were in agreement with a consecutive reversible mechanism of the form $Ag^+ + Cl^- \rightleftharpoons AgCl$; $AgCl + Cl^- \rightleftharpoons AgCl_2^-$ where the first stage represented a preequilibrium to the second stage and the forward and reverse rate constants of the second stage were $(4.1 \pm 0.1) \times 10^8$ l mol$^{-1}$ s$^{-1}$ and $(4.7 \pm 0.12) \times 10^6$ l mol$^{-1}$ s$^{-1}$, respectively. Some indications of the formation of a silver organic compound were observed. The period of incubation before precipitate formation ($t_0$) was determined. This obeyed the general rule $\log t_0 = -n \log \bar{c} + \text{const}$ where $\bar{c}$ is the geometrical mean of the initial ion concentration, and $n = 8.9 \pm 0.5$. Similar studies of the iodoacetic acid plus silver acetate system indicated formation of the complex $AgI_2^-$. (auth) (UK)

**19807** RADIOLYSIS OF ACIDIC AND AERATED SOLUTIONS OF HYDROGEN PEROXIDE. Ferradini, Christiane; Seide, Claus (Institut de Physique Nucleaire, Paris). Int. J. Radiat. Phys. Chem., 1: 219-28(Apr. 1969). (In French).

The yields of the radiolytic decomposition of $H_2O_2$ were measured in 0.4 mol/l solutions of $H_2SO_4$ at concentration intervals of $H_2O_2$ from 0.1 to 5 mol/l. In the interval from 1 to 5 mol/l the yields vary linearly with the concentration of hydrogen peroxide and with the reciprocal of the square root of the dose rate. A kinetic scheme was verified which allowed determination of the rate constant of the reaction $HO_2 + H_2O_2 \rightarrow OH + H_2O + O_2$, as $k = 0.20 \pm 0.01$ l mol$^{-1}$ s$^{-1}$. An examination of solutions less acid (pH = 1 and 1.5) points to the intervention of the equilibrium: $H_2O_2^+ \rightleftharpoons HO_2 + H^+$. (auth) (UK)

**19808** ONE ELECTRON OXIDATION AND P-TYPE DELAYED FLUORESCENCE OF AN AROMATIC AMINE STUDIED BY PULSE RADIOLYSIS. Bensasson, R. V.; Thomas, J. K. (Argonne National Lab., Ill.). Int. J. Radiat. Phys. Chem., 1: 185-97(Apr. 1969).

Both nanosecond and microsecond pulse radiolysis techniques were used to investigate the formation of the cation and triplet state of N,N,N',N'-tetramethyl-p-phenylenediamine (TMPD) in the radiolysis of organic liquids. In benzene solutions the triplet state of TMPD is mainly formed by energy transfer from the singlet and triplet excited states of benzene. The decay of the triplet TMPD is first order and is accompanied by delayed fluorescence. In cyclohexane and 3-methylpentane solutions a mixture of the triplet state and cation of TMPD are formed. The cation is formed by electron transfer from TMPD to the solvent cation, while neutralization of the TMPD cation leads to the triplet state. A significant yield of TMPD cation is formed in ethanol and isopropanol solutions. It is suggested that the cation is derived by electron transfer from TMPD to an oxidizing solvent radical ($G \approx 1.0$). The rate of electron transfer is $k = (4.5 \pm 0.5) \times 10^9$ l mol$^{-1}$ s$^{-1}$ in ethanol and $(5.5 \pm 1.5) \times 10^9$ l mol$^{-1}$ s$^{-1}$ in isopropanol. In the absence of TMPD the oxidizing radical disappears by first-order kinetics with $k = (1.7 \pm 0.5) \times 10^7$ s$^{-1}$ in ethanol and $k = (3.5 \pm 0.5) \times 10^7$ l mol$^{-1}$ s$^{-1}$ in isopropanol. (auth) (UK)

**19809** SOME TOPICS IN THE RADIATION CHEMISTRY OF AQUEOUS SOLUTIONS OF BENZENE. Kartasheva, L. I.; Pikaev, A. K. (Inst. of Physical Chemistry, Moscow). Int. J. Radiat. Phys. Chem., 1: 243-62(Apr. 1969). (In Russian).

The results of studies of radiolytic transformations in aerated, aqueous solutions of benzene at different dose rates and in aqueous solutions of benzene in the presence of ferrous ions and oxygen at different concentrations of $Fe^{2+}$, $C_6H_6$, and $H_2SO_4$ are described. From the study of dose rate effects in the ranges of 3.7 to 370 and $10^3$ to $3.6 \times 10^5$ RADs, it was found that in neutral aerated solutions of benzene the ratio of yields of phenol and muconic dialdehyde is practically independent of the dose rate. It is postulated that both phenol and muconic dialdehyde are formed by monomolecular decay of $O_2C_6H_6OH$ radicals. Chain reactions, in which organic peroxide compounds play an important part, occur in irradiation of sulfuric acid solutions of benzene in the presence of $Fe^{2+}$ ions and oxygen. The yields are characterized by high values. For example, the yields of $Fe^{3+}$, phenol, muconic dialdehyde, and hydrogen are respectively 66, 14, 8, and ≈3.5 molecules/100 eV for the aerated solution 0.4M $H_2SO_4$, $2.5 \times 10^{-4}$M $Fe^{2+}$ and ≈$10^{-2}$M $C_6H_6$. Possible mechanisms of radiolytic transformations in this system are suggested and the relative rate constants of some reactions are calculated. The possibility of the use of aerated aqueous solutions of ferrous ions in the presence of benzene for measuring doses not exceeding $4 \times 10^3$ RAD is considered. It is found that under certain conditions this system can be used for measuring doses in the range of 100 to $2.5 \times 10^3$ RAD. (auth) (UK)

## Radiochemistry

*Refer also to abstract 19697.*

**19810** OXIDATION STATES OF TIN NUCLIDES FORMED BY n, γ REACTIONS. Dehmer, J. L.; Wahl, A. C. (Washington Univ., St. Louis). J. Inorg. Nucl. Chem., 31: 562-5(Feb. 1969).

The results are reported for studied on the oxidation states of 27-hr $^{121}$Sn, 40-min $^{123}$Sn, and 9.6-min $^{125}$Sn formed by n,γ reactions on $^{120}$Sn, $^{122}$Sn, and $^{124}$Sn in the $2^+$ and $4^+$ oxidation states in aqueous solutions. The results for $^{121}$Sn and $^{123}$Sn show that both isotopes are formed predominately in the $2^+$ oxidation state from the n,γ reactions and that the oxidation state of the target nuclide has only a small effect. From three experiments in which $^{124}$Sn was a principal target nuclide, it was found that ~90% of the 9.6 min $^{125}$Sn was in the $2^+$ state. It was concluded that the very large recoil energies of fission products are not required for extensive reduction of high eer oxidation states to Sn(II); modest recoil energies (~100 eV) from n,γ reactions are sufficient. (P.C.H.)

**19811** ON THE CHEMICAL EFFECTS OF THE ISOMERIC TRANSITION $^{130m}$I → $^{130}$I IN BENZENE AND BENZENE–METHANOL MIXTURES. Kontis, S. S.; Katsanos, N. A. (Democritos Nuclear Research Centre, Athens). Z. Phys. Chem. (Frankfurt), 63: 161-7(Jan. 1969).

Chemical effects of the isomeric transition $^{130m}$I → $^{130}$I in benzene and benzene-methanol mixtures were studied. The results were compared with those obtained by others with different modes of activation of iodine. They are also briefly discussed on the basis of an intermediate complex hypothesis advanced earlier. (auth)

**19812** CHEMICAL EFFECTS ASSOCIATED WITH β-DECAY PROCESS. III. THE CHEMICAL BEHAVIOR OF $^{144}$Pr DECAYED FROM $^{144}$Ce(III)-EDTA COMPLEXES IN THE SOLID PHASE. Shiokawa, Takanobu; Kudo, Hiroshi; Omori, Takashi (Tohoku Univ., Sendai). Bull. Chem. Soc. Jap., 42: 436-9(Feb. 1969).

The chemical behavior of $^{144}$Pr formed by the $\beta^-$ decay of $^{144}$Ce in crystals of $^{144}$Ce(III) complexes with EDTA was investigated by means of ion-exchange techniques. The initial yield of $^{144}Pr^{3+}$ ion, which reflects the distribution of the $^{144}$Pr atoms in the crystal, is independent of the dissolving condition, but is affected by the amount of hydration in the crystal. Abnormal behavior of $^{144}$Pr atom was not found in the ammonium salt. These results suggest that in the solid phase $^{144}Pr^{3+}$ or its precursor may be produced as a result of multiple charging of the daughter following electron shake-off and internal conversion of γ rays. (auth)

## Separation Processes

*Refer also to abstracts 19652, 19665, 19678, 19693, 19744, 19769, 19775, 19922, and 21451.*

**19813** (AECD/CH-12) EXTRACTION OF ZIRCONIUM WITH MIXED SOLVENTS FROM NITRIC ACID SOLUTIONS. Awwal, M. A.; Idriss, K. M.; Ali, S. Masum (Atomic Energy Centre, Dacca (Pakistan)). Aug. 1968. 17p. Dep.

The extraction of Zr with four pairs of solvents such as trioctylphosphine oxide (TOPO)–thenoyltrifluoroacetone (TTA), TOPO–Primene JMT (PrJMT), tributyl phosphate (TBP)–TTA, and TBP–PrJMT has been investigated as a function of different extraction parameters. The distribution coefficient of zirconium has been studied with individual solvent as a function of nitric acid concentration and also with mixed pairs of solvents. Finally, the extractions of zirconium as a function of mixed solvent concentration have been studied from constant aqueous phase acid. Synergistic and antisynergistic extraction effects were observed. Mechanisms of extraction are explained for the solvation and adduct formation. (auth)

**19814** (BARC-374) TRILAURYLAMINE AS AN EXTRACTING AGENT FOR THE FINAL PURIFICATION OF PLUTONIUM DURING THE REPROCESSING OF IRRADIATED FUEL. Srinivasan, N.; Ramaniah, M. V.; Rao, C. L.; Khopkar, P. K.; Nair, G. M.; Singh, N. P. (Bhabha Atomic Research Centre, Bombay (India)). 1968. 30p. Dep.

Detailed studies on the trilaurylamine (TLA) extraction of plutonium were carried out in the presence and in the absence of several interfering ions. Optimum conditions for the extraction and different stripping conditions are suggested depending upon the end processing of plutonium. It was found that plutonium(IV) can be extracted with a high distribution coefficient (~300) from 2M $HNO_3$ by 20%(v/v) solution of TLA in xylene. Under these conditions the decontamination of plutonium from uranium is expected to be the best. An organic loading of nearly 27 mg/ml of plutonium was obtained and no third phase formation was noticed even at the maximum loading conditions. Presence of large quantities of uranium in the aqueous phase was found to result in a considerable decrease in the distribution coefficients for plutonium. However, most of the uranium coextracted to the organic phase was found to be easily removed by scrubbing with 0.5 N $HNO_3$. The backwashing of plutonium from the organic phase was found to be possible with 2M acetic acid or with 1M $H_2SO_4$. (auth)

**19815** (BM-RI-7175) AMINO ACIDS AS RETAINING AGENTS FOR SEPARATION OF RARE-EARTH ELEMENTS ON ION-EXCHANGE RESIN. Winget, J. Oscar; Lindstrom, R. E. (Bureau of Mines, Reno, Nev. Reno Metallurgy Research Center). Sept. 1968. 8p.

Amino acids were investigated in conjunction with rare earth separation by ion exchange to determine whether they can be utilized effectively as retaining agents for metal separation using ethylenediaminetetraacetic acid (EDTA) eluant at 85 to 90°C. Hydroxyethylethylenediaminetriacetic acid (HEDTA) and diethylenetriaminepentaacetic acid (DTPA) were the most effective amino

acids investigated. Elements of atomic numbers 39 and 57 through 68 were effectively retained, whereas elements of atomic numbers 69 through 71 passed through the retaining-agent band. Utilization of HEDTA or DTPA retaining agents allows an increase of 75% in the EDTA eluant concentration over that possible with hydrogen- or copper-retaining ions without precipitation occurring. Eighty-five percent recovery of the EDTA eluant collected before rare earth breakthrough and during elution of lutetium, ytterbium, and thulium, and essentially complete recovery of the HEDTA or DTPA retaining agents, are possible without extensive processing. (auth)

**19816** (BMwF-FBK-68-54) DISTRIBUTION OF $^{230}Th$, $^{232}Th$, AND $^{238}U$ IN LEACHING FRACTIONS OF URANIUM ORES. Born, H.-J.; Meyer, H.-G. (Technische Hochschule, Munich (West Germany). Institut fuer Radiochemie). Dec. 1968. 14p. (In German). Dep.

Three different uranium ores have been leached with sulfuric acid under normal conditions in industrial plants, and the yields of $^{238}U$, $^{230}Th$, and $^{232}Th$ in the solution have been determined. The results on two ores showed that with decreasing $H_2SO_4$ concentration the yield of $^{232}Th$ is diminished more rapidly than the yield of $^{230}Th$, leading to an enrichment of $^{230}Th$ concentration in the leach solution. This behavior is interpreted by the different genesis of $^{230}Th$ and $^{232}Th$ in the ore. The third ore showed a contrary behavior, which is discussed. (auth)

**19817** (CONF-680610) FLUORIDE VOLATILITY 1968. PROCEEDINGS OF THE ROCKY FLATS FLUORIDE VOLATILITY CONFERENCE, JUNE 24–25, 1968. Cleveland, J. M.; Thompson, M. A. (eds.) (Dow Chemical Co., Golden, Colo. Rocky Flats Div.). 208p. Dep. CFSTI.

Thirteen articles are included; separate abstracts were prepared for eleven. The remaining two articles on volatility studies with irradiated fuels and the Oak Ridge Gaseous Diffusion Plant fuel reprocessing program were previously published. (P.C.H.)

*For abstracts of individual papers see: 19691, 19818–19825 19922, and 20532.*

**19818** (CONF-680610–, pp 18-41) FLUORIDE VOLATILITY PROCESSES: FLUORINATION OF URANIUM AND PLUTONIUM. Levitz, N. M. (Argonne National Lab., Ill.).

A review is presented on programs conducted in the Chemical Engineering Division at Argonne that were concerned with reprocessing of nonirradiated simulated fuel materials by the fluoride volatility process. The first program discussed has to do with fully enriched alloy fuels: U–Zircaloy alloy clad with Zircaloy and U–Al alloy clad with Al. Another program was for $UO_2$ dispersed in stainless steel and $UO_2$ dispersed in graphite. Another type is sintered $UO_2$–$ZrO_2$ clad in Zircaloy similar to that seen in the Shippingport Pressurized Water Reactor. The main reactions involved in processing these fuels are tabulated and discussed. The basic difference in the handling of these fuels was the head-end step, namely, the chemical step or steps needed to separate the matrix material and to prepare the U for recovery by fluorination. In the case of the alloy fuels, both were done simultaneously. The matrix material was converted to a volatile form, while the U converted to a particulate form by the reaction, remained in the reactor mixed with the fluid bed of alumina. The alumina served as a heat-transfer medium in these processes. (P.C.H.)

**19819** (CONF-680610–, pp 42-50) FLUORIDE VOLATILITY LABORATORY STUDIES. Marshall, R. S. (Dow Chemical Co., Golden, Colo. Rocky Flats Div.).

Laboratory-scale investigations on two plutonium recoverable residues, incinerator ash and slag, are described. To remove Pu from incinerator ash, it was found that the ash had to first be hydrofluorinated at 650°C and then fluorinated. Plutonium removal by this method was 94 wt % and the final residue contained 0.8 wt % Pu, which is slightly over the 0.7 wt % discard limit. Silicon removal from incinerator ash was found to be more difficult than Pu. Plutonium (94 wt %) was removed from slag samples by gradual heating to 550°C during fluorination. Plutonium content in the final residue was only 0.3 wt %. The performance of a packed bed of $PuF_4$ heated to appropriate temperatures for the decomposition of kilogram quantities of $PuF_6$ without introducing impurities into the product is described. Data are given for neutron emission from samples of $PuF_3$, $PuF_4$, and $PuF_6$. (P.C.H.)

**19820** (CONF-680610–, pp 65-78) DEVELOPMENT OF VOLATILITY PROCESSES FOR THERMAL AND FAST REACTOR FUELS. Jonke, A. A. (Argonne National Lab., Ill.).

Potential and present applications for the fluoride volatility process are listed and discussed. These include the reprocessing of low-enrichment, high-enrichment, fast breeder, and light water, and LMFBR reactor fuels. (P.C.H.)

**19821** (CONF-680610–, pp 79-98) A FLUIDIZED-BED FLUORIDE VOLATILITY PILOT PLANT FOR PLUTONIUM PURIFICATION. Standifer, R. L. (Dow Chemical Co., Golden, Colo. Rocky Flats Div.).

The design and performance of a gram quantity static bed volatility system for purifying scrap plutonium from weapons production process and recovering plutonium from residues generated in the process are described. Experiments were started in December 1967. Current plans call for completion of a production prototype system by January 1970, and assuming continued favorable results, incorporation of a volatile fluoride process in a new plutonium recovery facility around 1974. (P.C.H.)

**19822** (CONF-680610–, pp 130-9) FLUORINATION OF ALL ENRICHMENTS OF URANIUM OXIDES. Crawford, J. G. (Goodyear Tire and Rubber Co., Akron, Ohio. Goodyear Atomic Corp., Portsmouth, Ohio).

The equipment, operating procedures, and system characteristics, for a uranium oxide to uranium hexafluoride conversion facility for processing 20,000 kg of uranium per year are described. Design of the flame-tower and associated subsystems, such as pneumatic unloading and transfer for oxide, feed screw and disperser for the tower, ash removal, filtering, cold trapping, and liquid $UF_6$ loading into cylinders, was dictated by the need for nuclearly safe geometry, so that all enrichments of uranium could be processed, and by the need for maximum protection of personnel from exposure to the uranium materials. Respiratory equipment is not required since the parts of the process, which are apt to allow release of airborne material, are additionally enclosed by glove boxes. (auth)

**19823** (CONF-680610–, pp 140-60) PROCESS CHEMISTRY OF NEPTUNIUM HEXAFLUORIDE. Trevorrow, L. E. (Argonne National Lab., Ill.).

The chemistry of $NpF_6$ under conditions related to operations that might be carried out in fluoride volatility processes for recovery of fissionable materials is discussed. This includes fluorination of Np(IV) compounds, reactions of $NpF_6$ with bromine, separation of $NpF_6$–$PuF_6$ mixtures by thermal decomposition, reactions of $NpF_6$ with $MgF_2$, reactions of $NpF_6$ with NaF, structural symmetry of $3NaF \cdot NpF_5$, and use of $NpF_6$ reactions with NaF for $PuF_6$–$NpF_6$ and $UF_6$–$NpF_6$ separations. (P.C.H.)

**19824** (CONF-680610–, pp 161-5) CRITICALITY CONSIDERATIONS IN FLUORIDE VOLATILITY PROCESSING. Schuske, C. L. (Dow Chemical Co., Golden, Colo. Rocky Flats Div.).

The effects of density, moisture, personnel shielding, and geometry on critical mass and dimension in criticality measurements on $^{239}Pu$ in fluoride volatility processing are discussed. Ideas that may be used to minimize restrictions for process equipment and result in practical dimensioned process equipment are included. (P.C.H.)

**19825** (CONF-680610–, pp 185-98) ENGINEERING OF A PRODUCTION PROTOTYPE FLUORIDE VOLATILITY SYSTEM. Heady, O. E. (Dow Chemical Co., Golden, Colo. Rocky Flats Div.).

The design of a production prototype fluoride volatility system is described. The prototype will be semicontinuous with a throughput of 12 kg of Pu/day. A high degree of remote control will allow the system to be operated from a control console. The processing of Pu by this method will greatly reduce the radiation exposure to the operating personnel. (P.C.H.)

**19826** (JEN-201-DMa/I-22) DISSOLUTION OF NUCLEAR FUELS. Uriarte Hueda, A.; Berberana Eizmendi, M.; H. Rainey, R. (Junta de Energia Nuclear, Madrid (Spain). Division de Materiales). 1968. 27p. (In Spanish). Dep.

A laboratory study was made of the instantaneous dissolution rate for unirradiated uranium metal rods and $UO_2$, $PuO_2$, and $PuO_2$–$UO_2$ pellets in boiling nitric acid alone and with additives. The uranium metal and $UO_2$ dissolved readily in nitric acid alone; $PuO_2$ dissolved slowly even with the addition of fluoride; $PuO_2$–$UO_2$ pellets containing as much as 35% $PuO_2$ in $UO_2$ gave values of instantaneous dissolution rate to indicate that they can be dissolved with nitric acid alone. An equation to calculate the time for complete dissolution was determined as a function of the instantaneous dissolution rates. The calculated values agree with the experimental values. Uranium dioxide pellets from various sources but with the same density varied in instantaneous dissolution rate. All the pellets, however, dissolved in the same time. The time for complete dissolution of $PuO_2$–$UO_2$ pellets, having the same composition, and the concentration of the reagents used are functions of the fabrication method. (auth)

**19827** (K-1770) ENGINEERING DEVELOPMENT OF AN ABSORPTION PROCESS FOR THE CONCENTRATION AND COLLECTION OF KRYPTON AND XENON. Third Summary Progress

Report, January–June 1968. Merriman, J. R.; Pashley, J. H. (Oak Ridge Gaseous Diffusion Plant, Tenn.). Mar. 27, 1969. Contract W-7405-eng-26. 15p. Dep. CFSTI.

A continuous absorption process for the separation of krypton and xenon from contaminated gas streams is being investigated in development studies at the Oak Ridge Gaseous Diffusion Plant. In this process, krypton and xenon are preferentially removed from an incoming gas stream by selective dissolution in a fluorocarbon solvent, such as refrigerant-12. The liquid stream is then subjected to a series of fractionation operations which yield a product gas stream, rich in the noble gases, and an essentially pure solvent stream, for recycle. The major part of the ORGDP program, i.e., pilot plant testing, is supplemented by conceptual plant design and optimization studies. Work on the assembly of a computer code package for use in the optimization studies was completed, with incorporation of sizing and cost estimating routines into the material balance program. (auth)

**19828** (KFK-839) KINETICS OF EXTRACTION OF METALS WITH ORGANOPHOSPHORUS COMPOUNDS. Baumgaertner, F.; Finsterwalder, L. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Heisse Chemie). Sept. 1968. 18p. Dep.

The extraction mechanism is discussed with regard to the chemical steps leading to the equilibrium state. Mass transfer studies were made on the extraction of uranyl nitrate and plutonium nitrate from an aqueous phase into a hydrogen solution of TBP. (M.C.G.)

**19829** (ORNL-4344, pp 291-327) MOLTEN-SALT PROCESSING AND PREPARATION. Whatley, M. E. (Oak Ridge National Lab., Tenn.).

Topics covered include: measurement of distribution coefficients in molten salt–metal systems, simulated molten salt–liquid bismuth contactor studies, reductive extraction engineering studies, continuous fluorination of molten salt, distillation of MSRE fuel carrier salt, relative volatility measurements by the transpiration method, preparation of $^{7}LiF-^{233}UF_4$ concentrate for the MSRE, development of the two-step process for preparation of $^{7}LiF-^{233}UF_4$ fuel concentrate for the MSRE, and process development for recovery of uranium from MSRE. (M.C.G.)

**19830** (ORNL-TM-2169) SORPTION OF FISSION PRODUCT (NIOBIUM, RUTHENIUM) FLUORIDES ON SODIUM FLUORIDE. Nogueira, E. D.; Cathers, G. I. (Oak Ridge National Lab., Tenn.). Apr. 1969. Contract W-7405-eng-26. 56p. Dep. CFSTI.

An experimental study of the sorption of some fission product (niobium and ruthenium) fluorides on fixed beds of sodium fluoride was made in order to obtain a better understanding of the sorption–desorption methods for purifying uranium hexafluoride. Two types of experiments were conducted. First, deep sodium fluoride beds that were subdivided into sections were used to investigate the removal of niobium (and ruthenium) pentafluorides from a gas stream as a function of temperature and bed height. Later, single layers of sodium fluoride particles were used to study the removal of niobium pentafluoride as a function of its concentration in the gas and of solid surface area. The sorption process was followed with the tracers $^{95}Nb$ and $^{103}Ru$. Experimental data were obtained in the temperature range 100 to 600°C and at niobium pentafluoride concentrations below a partial pressure of $5 \times 10^{-2}$ mm Hg. The results of this study indicate that the removal of niobium pentafluoride from the gas stream is a function of temperature, with a maximum at about 450°C, and of niobium pentafluoride concentration in the gas stream (apparent second-order mechanism); however, it does not depend on the surface area of the solid. One of the possible mechanisms proposed involves the existence of a gaseous niobium pentafluoride dimer, $Nb_2F_{10}$, which is sorbed on sodium fluoride with an apparent activation energy of about 9.0 kcal/g-mole. Information found in the literature seems to confirm the existence of this dimer. Interestingly, the study showed that neither niobium pentafluoride nor ruthenium pentafluoride was removed to any appreciable extent by sodium fluoride at temperatures above 550°C. This could provide a practical basis for a plutonium hexafluoride separation and purification method. (auth)

**19831** (ORNL-TM-2389) HEAD-END STUDIES OF SiC-COATED HTGR FUELS: UNIRRADIATED DRAGON COMPACT NO. 8232. Vaughen, V. C. A. (Oak Ridge National Lab., Tenn.). Feb. 1969. Contract W-7405-eng-26. 33p. Dep. CFSTI.

The first unirradiated Dragon fuel compact was crushed, sieved, and subdivided into replicate portions to test for the fraction of silicon carbide-coated beads broken in handling and heavy-metal recoveries and losses in the crush-grind-leach flowsheet and in the crush-burn-grind-leach flowsheet. Standardized experimental techniques were devised for these tests. Both process flowsheets gave greater than 99.9% recoveries of heavy metals. (auth)

**19832** (ORNL-tr-3016) SOLVENT EXTRACTION OF MONO-, DI-, AND TRIVALENT ELEMENTS IN THE PRESENCE OF DI-2-ETHYLHEXYLPHOSPHORIC ACID. Duboquoy, C.; Guillaumont, R.; Bouissiers, G. Translated for Oak Ridge National Lab., Tenn., from Radiochim. Acta, 8: 49-57(1967). 20p. Dep. CFSTI.

An abstract of this paper, prepared from the original language, appeared as NSA 21: 45219.

**19833** ZONE ELECTROPHORESIS ON PAPER IN INORGANIC ANALYSIS. COMMUNICATION 2. THE POSSIBILITY OF USING CITRIC ACID AS A UNIVERSAL ELECTROLYTE FOR THE SEPARATION OF IONS. Korchemnaya, E. K.; Naumova, V. I.; Ermakov, A. N. (Inst. of Geochemistry and Analytical Chemistry, Moscow). Zh. Anal. Khim., 24: 342-5(Mar. 1969). (In Russian).

Studies were made on the possibility of using citric acid as a universal electrolyte for separating ions. Complexes or simple salts of citric acid migrate as definitely outlined zones at different rates. The following ions were successfully separated: Sr, Ca; Sr, Ba; Ba, Ca, Zn, Cd; Fe(III), Co, Ni, Cr(VI); Mn(II), Fe(III); Fe, Co, Ni, U(VI); Mn(II), Ni, Co, Th, Cr(VI); Th, U(VI), Pb; and U(VI), Eu(III). (auth)

**19834** EXTRACTION OF URANIUM(IV) FROM HYDROCHLORIC ACID SOLUTION BY TRI-n-OCTYLAMINE IN BENZENE. Kojima, Takashi; Fukutomi, Hiroshi (Tokyo Inst. of Tech.). Bull. Tokyo Inst. Technol. (Engl. Ed.), No. 83, 87-102(Mar. 1968).

The distribution ratios for extraction of uranium(IV) ion from hydrochloric acid aqueous solution by tri-n-octylamine (TOA) in benzene were measured varying the concentrations of TOA, HCl, and uranium(IV) ion. It was found that the distribution ratio, D, is represented by the experimental equation $D = 1.56 \times 10^{-3}(HCl)^{2.74}[\overline{RHCl}]^3$ and that the extraction of uranium(IV) is represented as follows: $3\overline{RHCl} + UCl_4 = (\overline{RHCl})_3\overline{UCl_4}$. This reaction is also supported by the experimental results of the variation of chloride ion concentration in organic phase for the extraction of uranium(IV) ion. (NSA of Japan)

**19835** A STUDY OF THE MECHANISM OF THE ADSORPTION ON COLUMNS OF SALTS. THE SORPTION OF EUROPIUM ON CADMIUM OXALATE. Massart, D. L. (Proeftuinstratt, Ghent). Anal. Chim. Acta, 45: 183-6(Mar. 1969).

In an investigation of the possibility of using oxalates as the stationary phase for radiochemical column separation, the mechanism of sorption on such materials, and especially the sorption of europium on cadmium oxalate, were studied. "Non-stoichiometric" cadmium oxalate yielded sorption percentage of 99.5% or better; however, "stoichiometric" cadmium oxalate was an irreproducible column material for the sorption of microgram quantities of Eu, for example the sorption percentages obtained for 2 μg of Eu on 1 g of cadmium oxalate in 0.1 N nitric acid were 95.2%; 88.0%; 62.2%; and 17.8%. Cadmium oxalate presents two favorable characteristics as a column material, the capacity for the rare earths is very high and the attainment of equilibrium is fast so that flow rates of 1 ml/cm$^2$·min were possible. (D.H.M.)

**19836** SEPARATION OF URANIUM FROM PHOSPHORIC ACID BY REVERSED-PHASE COLUMN CHROMATOGRAPHY. Heunisch, George W. (Continental Oil Co., Ponca City, Okla.). Anal. Chim. Acta, 45: 133-6(Mar. 1969).

Uranium and phosphate can be quantitatively separated on a column containing tri-n-butyl phosphate on silica gel. Phosphate can be eluted with saturated aluminum nitrate solution before the elution of uranium with water. The procedure is simple, rapid, and versatile. (auth)

**19837** DISTRIBUTION COEFFICIENTS AND THE CATION-EXCHANGE BEHAVIOUR OF ELEMENTS IN HYDROCHLORIC ACID–ETHANOL MIXTURES. Strelow, F. W. E.; Van Zyl, C. R.; Bothma, C. J. C. (South African Council for Scientific and Industrial Research, Pretoria). Anal. Chim. Acta, 45: 81-92 (Mar. 1969).

Cation exchange equilibrium distribution coefficients with Bio-Rad $AG_{50}W$-X8, a sulfonated polystyrene resin, are presented for 45 elements in hydrochloric acid–ethanol media. The acid concentration range 0.1 to 3.0 M and the ethanol concentration range 0 to 95% are covered. The elements are arbitrarily arranged in tables according to their coefficients in aqueous hydrochloric acid. Possibilities for separations inherent in the system are demonstrated by elution curves for the multicomponent systems Fe(III)–U(VI)–Ca(II)–La(III); Cd(II)–Zn(II)–Fe(III)–Ca(II)–Ba(II); and In(III)–Ga(III)–Be(II)–Al(III)–Y(III). Some aspects in the elution behaviour of various elements are discussed. (auth)

**19838** EFFECT OF THE NATURE OF THE RETAINING ION ON THE DISPLACEMENT CHROMATOGRAPHIC SEPARATION OF RARE EARTHS WITH EDTA. Bruecher, Erno; Szarva, Pal (Kossuth Lajos Tudomanyegyetem Szervetlen- es Analitikai-Kemiai Tanszeke, Debrecen, Hungary). Magy. Kem. Foly., 75: 63-6(Feb. 1969). (In Hungarian).

In the displacement chromatographic separation of rare earth elements with EDTA, using $Cu^{2+}$, $Zn^{2+}$, and $Ni^{2+}$ as the retaining ions, the pH of the solution in the resin bed at the boundary of the rare earth transition metal bands increases by 1 to 1.5 pH units when the exchange reactions take place between the transition metal ions and the rare earth–EDTA complexes. This is due to the higher stability constants of the protonated transition metal–EDTA complexes, which are about three orders of magnitude higher than those of the rare earth–EDTA complexes. An increase of the pH of the solution results in a decrease of the rate of the exchange reactions of the central ion of rare earths–EDTA complexes, which leads to a decrease of the sharpness of the rare earth band front. Using rare earth elements as retaining ions, the break-through curves are steeper and it is possible to use EDTA solutions of higher concentration and pH for the separation of lighter rare earths on development columns in rare earth form of higher atomic number. (auth)

**19839** THE STUDY OF CHROMATOGRAPHIC SEPARATION OF $UO_2^{2+}$ FROM SOME FISSION PRODUCTS ON THE VIONIT CS-2 RESIN. Marcu, Gheorghe; Sacelean, Viorel. Stud. Univ. Babes–Bolyai, Ser. Chim., 13: No. 2, 89-91(1968). (In Rumanian).

The Romanian cationite Vionit CS-2 may be used for the rapid separation of $UO_2^{2+}$ from $Cs^+$ $Sr^{2+}$ + $Y^{3+}$, and $Eu^{3+}$ on microcolumn. The separation of $UO_2^{2+}$ from $Zn^{2+}$ is very difficult since the separation coefficient is near unity. The elution of $UO_2^{2+}$, $Zn^{2+}$, and $Cs^{2+}$ was performed using the 2M $NH_4SCN$ solution in 0.2 M HCl, while for $Sr^{2+}$ + $Y^{3+}$ and $Eu^{3+}$ the 2M $NH_4CH_3COO$ solution was used. (auth)

**19840** SEPARATION OF LANTHANUM FROM URANIUM USING PAPER ELECTROPHORESIS. Tomus, Minerva; Totan, Maria. Stud. Univ. Babes–Bolyai, Ser. Chim., 13: No. 2, 49-52 (1968). (In Rumanian).

The formation of the compound $[La(CH_3COO)_3]^0$ was studied by paper electrophoresis. Calculation of the stability constant yielded $\lg \beta = 2.97$. The electrophoretic mobilities of the $La^{3+}$ and $UO_2^{2+}$ ions were calculated in 0.5 M acetic acid medium at different pH values using $^{140}La$. Results established that the method of paper electrophoresis may be successfully applied for the separation of $La^{3+}$ from $UO_2^{2+}$ in acetic acid medium. The experiment lasted 30 minutes. (auth)

**19841** PROCESS FOR FRACTIONATING LANTHANIDE MIXTURES CONTAINING CERIUM. Bauer, Donald J.; Lindstrom, Roald E. (to Secretary of the Interior). U. S. Patent 3,425,793. Feb. 4, 1969. Filed June 8, 1966.

A cerium- and lanthanum-containing lanthanide solution is contacted with ozone, while the solution is maintained at a pH at 1.0 to 7.0 and a temperature of 20 to 100°C, to precipitate out the cerium and to leave the lanthanum in solution. At a pH of 1.0 to 5.5 and a temperature of 20 to 50°C, cerium can be separated from heavier lanthanides in the same manner. (Offic. Gaz.)

**19842** LABORATORY SCALE REACTOR FUEL REPROCESSING. Tolic, Aleksandar (Boris Kidric Inst., Belgrade); Pavasovic, Vladeta. Nukl. Energ., 5: No. 2, 21-4(1968). (In Serbo-Croatian).

Technological procedures for the processing of spent nuclear fuels and a laboratory scale plant are described. Experimental results of the reprocessing of fuel elements from the RA reactor at the Boris Kidrič Institute are discussed. (J.G.B.)

**19843** STUDY OF THE FORMATION OF THE COMPLEX COMBINATIONS OF $Ce^{3+}$, $Eu^{3+}$, $Sr^{2+}$, AND $UO_2^{2+}$ IN NITRILOTRIACETIC ACID MEDIUM BY PAPER ELECTROPHORESIS. Marcu, Gheorghe; Tomus, Minerva; Solea, Maria. Stud. Univ. Babes–Bolyai, Ser. Chim., 13: No. 2, 15-19(1968). (In Rumanian).

The formation of complex combinations of $Ce^{3+}$, $Eu^{3+}$, $Sr^{2+}$, and $UO_2^{2+}$ was studied in nitrilotriacetic acid medium by paper electrophoresis. The sum of electrophoretic mobilities of the respective ions was calculated, establishing the possibility of separating $Eu^{3+}$, $Ce^{3+}$, and $Sr^{2+}$ from macroamounts of uranium at pH = 6 to 6.5 in 0.05M nitrilotriacetic acid medium. The stability constants of the compounds formed were calculated, namely, $\lg \beta_3 = 8.45$ for $[CeX]^0$, $\lg \beta_2 = 9.10$ for $[EuX]^0$, $\lg \beta_2 = 6.42$ for $[SrX]^-$ and $\lg \beta_2 = 7.88$ for $[UO_2X]^-$. (auth)

**19844** COLLECTION OF TRACES OF METALS ON CARBOXY CELLULOSE CATION-EXCHANGER. Schulek, E.; Remport-Horvath, Zs.; Lasztity, A.; Koeroes, E. (Eoetvoes Lorand Univ., Budapest). Talanta, 16: 323-9(Mar. 1969).

Carboxy cellulose ("C-cell") is a cation-exchanger based on cellulose and having carboxyl functional groups with pK 3.46 ± 0.05 at 20 ± 1° in 1M sodium chloride. The capacity of the exchanger is pH-dependent and the maximum is 0.22 mequiv/g. The capacity is also influenced by the dielectric constant of the medium and by the swelling of the cellulose. C-cell is suitable for the collection of metal ion impurities from aqueous and nonaqueous media. Amongst ions studied were Ba(II), La(III), Pr(III), Sr(II), $UO_2$(II), Y(III), etc. (auth) (UK)

**19845** METHOD OF PROCESSING NUCLEAR FUEL BY SELECTIVE ClF FLUORINATION WITH SEPARATION OF $UF_6$ AND $PuF_4$. Camozzo, Giovanni; Coenen, Francois; Francesconi, Aldo; Goossens, Walter; Pierini, Giancarlo; Schmets, Jean J.; Stynen, Adolf (to Atomic Energy Commission). U. S. Patent 3,429,669. Feb. 25, 1969. Priority date Sept. 6, 1966, Luxembourg.

Nuclear fuels are reprocessed by reacting them with chlorine monofluoride, which converts the uranium to volatile $UF_6$ and the plutonium to nonvolatile $PuF_4$. The chlorine produced in the reaction is separated from the $UF_6$ by distillation and reacted with fluorine to produce more chlorine monofluoride. (auth)

**19846** INDUSTRIAL PROCESSING OF PLUTONIUM. Schneider, V. (Alpha-Chemie und Metallurgie GmbH, Leopoldshafen, Ger.). Atompraxis, 15: 29-31(Jan.-Feb. 1969). (In German).

As a result of growing demand the processing of plutonium to a reactor fuel increasingly becomes a field for industrial activity. The characteristics of fuel rods for fast and thermal reactors and the necessary safety precautions to be taken in the processing of plutonium are indicated, and the flow schemes for the fabrication of pelletized and vibration-compacted fuels, respectively, are discussed. (auth)

**19847** AN INSTALLATION PERMITTING MONITORING OF RADIOACTIVE SAMPLES. Berthaud, Jean; Palli, Claude; Paradis, Yves (to Commissariat a l'Energie Atomique). British Patent 1,145,176. Mar. 12, 1969, Priority date Dec. 2, 1966, France.

A remote installation for monitoring the radioactivity of samples, specifically samples from fuel reprocessing, is described in which the operation for preparation of the sample is completely separated from the counting operation by screening of the counting unit. The preparation unit consists of a distributor of dishes for receiving the solution to be monitored, a pipette to supply the solution to each dish and possibly to dilute the solution, drying means for the solution, and automatic transmission means for transferring the dish to the transfer system connecting the preparation unit to the counting unit. The transfer system is made up of a guide tube extending along the passage connecting the preparation and counting units, and motor means entraining a sliding carriage and a rider for supporting the dish containing the prepared sample. The rider is mounted on the sliding carriage with a degree of freedom permitting it to be moved relative to the carriage by control means to apply the rider against the measuring instrument associated with the transfer system. The measuring unit is a scintillation-type device. (B.L.M.)

**19848** SEPARATION OF ZIRCONIUM BY THIN-LAYER CHROMATOGRAPHY. Oguma, Koichi (Government Chemical Industrial Research Inst., Tokyo). Talanta, 16: 409-12(Mar. 1969).

The thin-layer chromatographic separation of a number of metal ions, such as Sc, Y, Zr, La, Sm, Th, U(VI), Bi, Cu, Hg, Pb, Co, Ni, In, Mg, Cd, Zn, Fe, Al, and Ca, with solvent mixtures of mesityl oxide, ethanol, and 5M nitric acid on silica gel-cellulose (5 : 1) thin-layer plates is reported. Zirconium remains stationary while the other metal ions move with the solvent, thus allowing a selective separation of zirconium from about 20 metal ions in ratios ranging from 100 : 1 to 1 : 100. Mixtures of various metal ions can also be separated. (auth) (UK)

**19849** PRECIPITATE FLOTATION. IV. FLOTATION OF SILVER, URANIUM AND GOLD. Mahne, E. J.; Pinfold, T. A. J. Appl. Chem. (London), 19: 57-9(Feb. 1969).

The conditions for the flotation of silver using α-nitroso-β-naphthol and β-nitroso-α-naphthol, that of uranium using α-nitroso-β-naphthol and benzoylacetone, and that of gold using phenyl-α-pyridylketoxime were examined. Recoveries of over 90% were possible from $5 \times 10^{-5}$ M solutions of silver, $10^{-4}$ M solutions of uranium (VI) and $3 \times 10^{-4}$ M solutions of gold (III).

Extractions were best in the pH range 7 to 9, 6 to 9, and 3 to 5, respectively. Silver could be separated from 10-fold molar excesses of copper, zinc, and lead; uranium from 10-fold molar excesses of gold and iron and 100-fold molar excesses of sulfate and manganese; and gold from a 10-fold molar excess of uranium. Methods are suggested whereby redispersion in precipitate flotation can be avoided. The efficiency of this kind of flotation is considered. (auth) (UK)

**19850** NEPTUNIUM RECOVERY PROCESS. Reas, William H. (to General Electric Co.). U. S. Patent 3,432,276. Filed Nov. 17, 1966.

A process is described for reprocessing irradiated fuel from chain nuclear fission reactors. The method also discloses an improved chemical process for separating neptunium from plutonium (even in the presence of uranium) in solutions of such materials formed by dissolution of such reactor fuel. In this process the bulk of the fission products formed by irradiation of the fuel are first separated as a mixture from the uranium and transuranics such as neptunium and plutonium by extraction with an organic solvent, and the plutonium and the neptunium are separated in sequence. This involves a unique procedure for plutonium and neptunium valence control which permits their efficient separation from one another. (Offic. Gaz.)

**19851** INVESTIGATIONS ON THE DECONTAMINABILITY OF SURFACES CONTAMINATED BY RADIOACTIVE NUCLIDES. Otto, R. (Institut fuer Angewandte Radioaktivitaet, Leipzig). Isotopenpraxis, 5: 27-34(Jan. 1969). (In German).

Experiences with the decontaminability of paints, epoxide resins and vinoflex masses, plastics, and enamels are presented. The samples were principally contaminated by a carrier-free aqueous $^{90}Sr(NO_3)_2$ solution, in some cases by a weak nitric acid solution of a fission product mixture (age: 20 to 30 days) or by a carrier-free aqueous $^{65}Zn(NO_3)_2$ solution. Decontamination was, in general, carried out by alkaline oxidizing and acid reducing solutions, but also by other solutions, e.g., free from mineral acids or alkalines. According to the results of the experiments, some references are made to the applicability of materials in nuclear plants and radiochemical laboratories. (auth)

**19852** SEPARATION OF THE OXYGEN ISOTOPES BY RECTIFICATION OF MOLECULAR OXYGEN. Kovalenko, A. E.; Zel'venskii, A. D. (Moscow Chemical-Technical Inst.). Isotopenpraxis, 5: 20-6(Jan. 1969). (In Russian).

By means of simple distillation, the separation factor in the rectification of molecular oxygen in the temperature range from 78.8 to 90.4°K was measured for the oxygen isotopes $^{16}O$ and $^{18}O$. The maximum loading and the hydraulic resistance of the steel packing (2 × 2 × 0.2 mm) at different pressures (from 240 to 700 torr) were evaluated. Experiments were described for the separation of the oxygen isotopes in a packed laboratory column. The HETP value of the column and its dependence on temperature and pressure were investigated. (auth)

**19853** ENRICHMENT OF NATURAL SILICON ISOTOPES WITH A SEPARATION TUBE. Meinrenken, J. (Univ., Goettingen, Ger.). Z. Phys. Chem. (Frankfurt), 63: 205-7(Jan. 1969). (In German).

Concentration of $^{28}Si$, $^{29}Si$, and $^{30}Si$ in silicon compounds in ring slit separation tubes is described. Conditions for optimum separation were studied. (M.C.G.)

**19854** ENRICHMENT OF $^{6}Li$ BY ION EXCHANGE. Hagiwara, Zenzi; Takakura, Yoshihisa (Tohoku Univ., Sendai). J. Nucl. Sci. Technol. (Tokyo), 6: 153-4(Mar. 1969).

Enrichment of $^{6}Li$ by the displacement technique is described. Twelve columns containing Dowex 50 W, X-12, 50 to 100 mesh were connected in series and used for retaining the lithium. Each column consisted of a resin bed 22 mm in inner diameter and 1000 mm long. After elution of 75 band lengths of the Li band with a starting composition of 7.2% $^{6}Li$, the $^{6}Li$ was enriched to 15% at the rear edge of the adsorption band. (M.C.G.)

**19855** CATION-EXCHANGE BEHAVIOUR OF SEVERAL ELEMENTS IN HYDROBROMIC ACID-ORGANIC SOLVENT MEDIA. Korkisch, J.; Klakl, E. (Univ. of Vienna). Talanta, 16: 377-91(Mar. 1969).

The cation-exchange characteristics of 19 elements in hydrobromic acid-organic solvent media were investigated. These included $UO_2$(II), Th(IV), Ce(III), Sr(II), etc. In these systems the batch distribution coefficients of the metal ions were determined, using the strongly acidic cation exchange resin Dowex 50, X8. Methanol, ethanol, n-propanol, isopropanol, methyl glycol, acetone, tetrahydrofuran, and acetic acid were used as the organic solvents. The conditions most suitable for the quantitative separation of the elements are indicated and discussed. Several examples of successful separations are tabulated. (auth) (UK)

**19856** SORPTION CHARACTERISTICS OF THE CESIUM-GRAPHITE SYSTEM AT ELEVATED TEMPERATURES AND LOW CESIUM PRESSURES. Milstead, C. E. (Gulf General Atomic Inc., San Diego, Calif.). Carbon, 7: 199-200(Feb. 1969).

Studies of the sorption characteristics of Cs on nuclear grade graphite reported previously [NSA 20: 36799] were extended to lower Cs pressures. Measurements at 800, 900, 1000, and 1100°C under Cs pressures in the range $10^{-11}$ to $10^{-4}$ atm gave results of $10^{-4}$ to 1 mg Cs/g graphite. The results are related to the Freundlich and Langmuir isotherms. (UK)

**19857** CATION-EXCHANGE SEPARATION OF HAFNIUM AND ZIRCONIUM FROM ACCOMPANYING IONS. Korkisch, J.; Orlandini, K. A. (Argonne National Lab., Ill.). Talanta, 16: 45-9(Jan. 1969).

Hafnium and zirconium were not retained on the strongly acidic cation exchange resin Dowex 50 from a mixture containing methanol and 12M nitric acid (19:1) which was 0.1M in trioctylphosphine oxide. On the other hand most other elements investigated were strongly adsorbed on the resin from this medium, so that they could be readily separated from hafnium and zirconium. These elements included titanium, rare earths, alkali metals, alkaline earth metals, iron, cobalt, manganese, and zinc. This separation technique was found to be suitable for the separation of tracer and milligram amounts of hafnium and zirconium from accompanying metal ions. If in place of methanol other organic solvents such as acetone, tetrahydrofuran, and methyl glycol were used, the selectivity of the separation of zirconium and hafnium from the other elements was decreased. The same effect was observed when hydrochloric acid was used in the mixtures instead of nitric acid. (auth) (UK)

**19858** SOLVENT EXTRACTION AND SEPARATION OF STRONTIUM AND BARIUM WITH 4-ACYL DERIVATIVES OF 1-PHENYL-3-METHYL-PYRAZOLONES-5 AND COMPARISON WITH THENOYLTRIFLUOROACETONE. Mirza, M. Y.; Aziz, A. (Pinstech, Nilore, Rawalpindi, Pakistan). Int. J. Appl. Radiat. Isotop., 20: 135-9(Feb. 1969).

The solvent extraction behavior of strontium and barium with various 4-acyl derivatives of 1-phenyl-3-methyl-pyrazolones-5 (ethoxy, acetyl, butyryl, capryl, benzoyl) in methyl isobutyl ketone was examined and compared with PMCyP (1-phenyl-3-methyl-4-capryl-pyrazolone) and TTA in various organic solvents. After a critical survey of the relevant factors and determining the optimum conditions, a method is proposed which gives clean separation of strontium from barium. The procedure was checked by separating $^{85}Sr$ activities from a synthetic mixture containing 200 $\mu$Ci $^{85}Sr$ and 200 $\mu$Ci $^{139}Ba$. More than 80% added strontium activities were recovered in less than 6 min with a decontamination of $1 \times 10^5$ from barium in a single step. (auth) (UK)

# EARTH SCIENCES

## Geology and Hydrology

*Refer also to abstract 21609.*

**19859** URANIUM DISTRIBUTION IN ARAL SEA SEDIMENTS. Kochenov, A. V.; Baturin, G. N. (Inst. of Oceanography, Moscow). Oceanology (USSR) (Engl. Transl.), 7: 484-7(1967).

Sediment samples were taken by bottom grab in the period August–October 1965. Uranium was determined chemically by the pearl-luminescent method. Great similarity was revealed on comparison of the areal distribution of uranium in the Aral Sea and a bottom sediment chart. The main types of sediment differ clearly in terms of their U content. The least U (0.0001 to 0.0002%) was noted in the sand and silty ooze of the coastal zone; U content increased in the calcareous and argillaceous sediments of the central areas of the basin to 0.001%. Similar high contents were noted in the argillaceous sediments of the northern bays and the semi-isolated bays of the eastern shore. At the junction between fresh river water and salt seawater, U content was as low as throughout the coastal zone of sandy and silty oozes, between 0.0001 and 0.0005%. There is a distinct correlation between uranium content in Aral Sea sediments and organic matter. It appears that as much U is annually supplied to the bottom sediments as is brought in by the rivers, i.e., part of the U enters the basin in solution and passes into the sediment, as a result of which the latter is enriched to several times the level of the suspended matter of the river. This explains the increased abundance ratio of uranium in the sediments of the central areas of the Aral Sea. The distribution of U in the water over the area of the sea is uneven and to some extent related to general salinity; U content around the river mouths where the freshening effect of the rivers is felt is (3 to 3.5) $\times 10^{-5}$ g/liter, whereas in the central areas of the sea it increases to (5 to 6) $\times 10^{-5}$ g/liter. The relatively low extraction of U into the sediment from Aral water is apparently to be explained by its high carbonate content and oxygen saturation, and by the low content of the organic component in the sediment. (BBB)

**19860** THORIUM IN MINERAL BONE RESIDUES. Kovalev, V. A. (Lab. of Geochemical Problems, Minsk). Dokl. Akad. Nauk BSSR, 11: 717-18(Aug. 1967). (In Russian).

The stationary valence of thorium and the low solubility of its natural compounds leads to a sharp decrease in the abundance ration of thorium to uranium in water in comparison with erupted rocks. The mobility of thorium in the supergene zone can be increased by the action of organic materials. An example of this is its increased concentration in certain phosphated bone fragments. (tr-auth)

## Meteorology

*Refer also to abstracts 19872 and 19962.*

**19861** (A-AC-82/G/L-1262) DEPOSITION OF RADIOACTIVE DUST AND ITS ELIMINATION FROM THE ATMOSPHERE BY PRECIPITATION. Makhon'ko, K. P. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow). 1968. 42p. (In Russian). Dep.

Literature on radioactive fallout and mechanisms affecting its removal from the atmosphere is briefly reviewed. Factors contributing to fallout levels include natural products of radon and thoron decay from the earth's surface, radioactive waste from industrial sources, and particles from nuclear explosions. The removal of radioactive fallout from the atmosphere is accomplished by gravitational forces, turbulent transfer, and precipitation scavenging. The influence of each of these factors is discussed with emphasis on precipitation scavenging as an atmospheric self-purification process. (TTT)

**19862** (AERE-R-5899) RADIOACTIVE FALLOUT IN AIR AND RAIN RESULTS TO THE MIDDLE OF 1968. Cambray, R. S.; Fisher, E. M. R.; Brooks, W. L.; Peirson, D. H. (Atomic Energy Research Establishment, Harwell (England)). Dec. 1968. 55p. Dep. CFSTI. UK 8s. 0d.

Samples of atmospheric dust and rainwater were collected from the United Kingdom and elsewhere, and results are presented of the analyses of these samples for various fission products and certain other radionuclides. The concentrations of the long-lived fission products $^{137}Cs$ and $^{90}Sr$ in air in the United Kingdom were, in the first half of 1968, similar to those for the first half of 1967; the deposition was also similar, although the concentrations in rainwater were about 25% less than those in 1967. The Chinese explosion of June 17, 1967 contributed about half of the long-lived activity in the spring and summer of 1968, and the explosion of December 24, 1967 contributed about 10% of the total. The rate of deposition was small compared with earlier years and was approximately equivalent to the loss by radioactive decay of the $^{137}Cs$ and $^{90}Sr$ already deposited. An estimate is made of the world-wide deposition of $^{90}Sr$ in rain to the end of 1967. The British network for world-wide sampling of rainwater is compared with the American network. There is close agreement between the estimates of world-wide deposition from the two networks and also from the American soil sampling program. Measurements of short-lived fission products from the Chinese explosion of December 24, 1967 and the French tests of July to September 1968 are given in an appendix. Small amounts of short-lived fission products from the French tests have been detected in the United Kingdom. (auth)

**19863** (CONF-680507–, pp 49-64) NATURE AND BEHAVIOR OF LOCAL FALLOUT. Miller, Carl F. (URS Corp., Burlingame, Calif.).

Local fallout from a nuclear detonation on or near the surface of a silicate base soil consists mainly of two general types of particles: glasses and crystals. The frequency distribution of the fallout particles landing at a point is, therefore, bimodal (unless one type is missing). The radioactive composition of each particle type is fairly uniform with the refractory fission products more highly concentrated within the glassy particles (more or less in proportion to particle volume) and with the volatile fission products and fission products with volatile precursors more highly concentrated on the surface of the crystalline particles. In the fallout process, a tendency is exhibited for small particles to be carried down by the larger particles through agglomeration, attachment, or mutual entrainment. Under conditions of low surface wind speeds and high humidity, deposits are quite uniform on all exposed horizontal surfaces; vegetation, if sufficiently dense, will retain 100 percent of the depositing particles. Under conditions of high surface wind speeds and low humidity, the deposits on exposed surfaces are not uniform; the particles are not efficiently retained by sloped roofs and vegetation and the particles tend to drift into depressions and wind-protected locations. Freshly deposited particles are fairly rapidly removed from vegetation, sloped roofs, or smooth paved areas by wind of moderate speeds and redistributed to wind-protected locations and to rougher unpaved areas. (auth)

**19864** (CONF-680507–, pp 65-83) BASIC CHARACTERISTICS OF NUCLEAR RADIATION FROM FALLOUT. Cook, C. Sharp (Naval Radiological Defense Lab., San Francisco, Calif.).

The basic characteristics of the ionizing radiations that are emitted at the time of and following the detonation of a nuclear weapon are discussed, with particular emphasis given to the delayed gamma radiations that are associated with a burst of a nuclear weapon near the surface of the earth. In addition, a brief discussion is given of the concept of local fallout and the effects that differing detonation conditions have on the characteristics of the ionizing radiations that are observed. The main topic is the nature of gamma radiations that are emitted by radioactive sources that are distributed on the surface of the earth, as is expected in the case of local fallout, with some discussion of the effort that has been made to calculate the radiation fields expected from a distributed, planar source and of the experimental observations of radiations from sources that have been distributed to simulate fallout sources, as well as real fields of local fallout that were produced at the Nevada Test Site. A brief mention is also made of the radiation expected from neutron induced activities in soils. (auth)

**19865** ISOLATION OF RADIOACTIVE FALLOUT PARTICLES FOR MICROSCOPICAL EXAMINATION. Svihla, G. (Argonne National Lab., Ill.). Microscope (Brighton), 17: 25-8 (Jan. 1969).

Radioactive particles collected in an air sampler on asbestos fiber paper were isolated for microscopical examination. Radioautography was used to locate the particles at each of several dilution stages. Dilution was done in small drops of immersion oil on microscope slides that were covered with thin Saran plastic film prior to radioautography. The registration of autograph with slide was facilitated by brief exposure of the x-ray film to light in order to record ink marks made on the specimen slide as registration marks when the film was processed. A particle 10 microm-

eters in diameter with an activity of 335 pCi was easy to isolate. Particles 2 to 3.5 micrometers in diameter with activities of 23 to 163 pCi were a little more difficult to isolate, because of their smaller size and lower radioactivity. (auth)

**19866** ISOTOPIC STUDY ON METEORIC PRECIPITATION. Miyake, Yasuo (Meteorology Research Inst., Tokyo); Matsubaya, Osamu. Pap. Meteorol. Geophys. (Tokyo), 19: 243-66(July 1968).

The $^{18}O$ content in cloud droplets is higher in a closed system than in an open system. It is also higher under a nonequilibrium condition than under an equilibrium condition. In case of the frontal type of precipitation, the observed variation with time in $^{18}O$ content agrees fairly well with the calculation using an open model. The change in $^{18}O$ content in a convective shower, which gives snow pellets, can be explained by an open model. The isotopic exchange between falling raindrops and vapor is more effective in enriching heavier isotopes than evaporation. The calculated rate constant of isotopic exchange reaction between falling raindrops and vapor is about half of that given by Friedman et al. (1962). A smaller amount of isotopic exchange than was calculated was observed in rainwater. The relationship between D and $^{18}O$ contents in precipitation under an equilibrium condition can be expressed as an approximate straight line starting from the original point with a slope less than $(\alpha_D - 1)/(\alpha u_O - 1)$ in the region of slight isotopic fractionation. Deviations from the straight line are explained by the effect of kinetic processes. The downward shift below the line is due to kinetic evaporation, while the upward shift is due to either the supply of source vapor under a kinetic condition or isotopic exchange between raindrops and vapor that has evaporated under a kinetic condition. A constant term in Craig's equation for the relation between D and $^{18}O$ contents is derived by the fact that $^{18}O$ content in source vapor is lower by 1.2‰ on an average as compared with D content. (NSA of Japan)

**19867** BEHAVIOR OF AEROSOLS FORMED BY CLUSTERING OF MOLECULES AROUND GASEOUS IONS. Vohra, K. G.; Subba Ramu, M. C.; Vasudevan, K. N. (Bhabha Atomic Research Centre, Bombay). Atmos. Environ., 3: 99-105(Mar. 1969).

The behavior of aerosols formed by the clustering of vapor molecules around negative gaseous ions was studied using thorium-B atoms as tracer. Small negative ions of high mobility were first converted to large negative ions of low mobility by passage through a flask containing the liquid whose vapor was to be studied, using nitrogen as the carrier gas. The large ions so formed consisted of clusters of molecules of the vapor. These clusters were found to be stable even after the charge was lost, and behaved as a submicron aerosol. This aerosol, along with vapor and carrier gas, was introduced into a neoprene reservoir. In the reservoir the aerosol grew in size by coagulation and also probably by the diffusion of vapor molecules to the surface of the particles. Mean residence time of the aerosol particles in the neoprene reservoir at different times of growth was measured by introducing thoron gas in the reservoir and studying the change in activity due to thorium-B with time. The mean aerosol particle size at different times was estimated from the residence time in the reservoir. The aerosols investigated were the products of very early stages of nucleation by ions. The possible role of this mechanism in the formation of natural condensation nuclei is discussed. (auth)

**19868** PRECIPITATION OF FISSION PRODUCTS FROM THE ATMOSPHERE IN DEBRECEN, HUNGARY, DURING 1966 AND 1967. Szalay, A.; Csongor, E. (Inst. of Nuclear Research, Debrecen, Hungary). Acta Phys. Acad. Sci. Hung., 25: 279-86 (1968).

Results of the measurements relating to the beta activity of fission products in atmospheric precipitation during 1966 and 1967 are discussed. It can be ascertained from the summarized data of recent years that the fission product content of the precipitation decreased rapidly with an average decontamination half period of 0.7 year. With respect to the quarterly summarized data of the last two years a nearly constant activity level can be observed which is due to sporadic atmospheric nuclear tests. Fresh fission products with a short half period (originating from the Chinese nuclear test of Oct. 27, 1966) were detected in the precipitation by means of the gamma spectrometric method. Beryllium-7 produced by cosmic rays was separated chemically from the precipitation and the $^{7}Be$ activity of the precipitation determined by a gamma spectrometer. It amounts to 88 dpm/liter. (auth)

## Mineralogy and Exploration

*Refer also to abstracts 20027 and 20487.*

**19869** (AEC-tr-7034) URANIUM DEPOSITS IN NIGER. Bigotte, G.; Obelliane, J. Translated from Miner. Deposita, 3: 317-33(1968). 27p. Dep. CFSTI.

A review of the discovery and prospecting for uranium minerals in Niger is presented. The first indices were found in conjunction with those of copper in the Azêlik region (Agadès District). Aerial, ground, and exploratory (subsoil tests) prospecting was carried out for more than eight years. This established the extent of the geological setting in which uranium-bearing concentrations originated, and which determined the factors favorable for stratiform uranium mineralization to an extent economically exploitable. Particular stress is laid on the tectonics of the crystalline base, the hyperalkaline vulcanism, and the climatic changes. (auth)

**19870** ON THE PRESENCE OF URANINITE IN THE SAND ON THE BEACH OF QUIBERON (MORBIHAN). Coppens, Rene; Mayanda, Marcel (Centre de Recherches Radiogeologiques, Nancy). Compt. Rend., Ser. D, 268: 1016-18(Feb. 17, 1969). (In French).

Sand on the beach at Quiberon of very weak radioactivity was found to contain small amounts of uraninite crystals. Apparently this mineral has resisted erosion over the years. It was found that these crystals arise from the granite of Quiberon. Also, the conditions in France seem to be favorable for the formation of these deposits. Further studies will be made on the formation of these deposits in granite and also the lack of the deposits in granite. (P.C.H.)

**19871** RUM JUNGLE URANIUM PROJECT. Stewart, J. R. S. Afr. Mining Eng. J., 79: 844-50(Oct. 11, 1968).

During the period of maximum U production in Australia, 5 treatment plants operated in 4 areas, all producing yellowcake. The discovery of U at Rum Jungle in 1949 was by a local prospector. Prospecting and development operations were begun by the Bureau of Mineral Resources in 1950. Territory Enterprise Pty. Ltd. was formed in 1952 for management of the Rum Jungle enterprise. Opencut mining of the deposit began in 1954, nearly simultaneously with opening of the first ore treatment plant. Production from the original ore body was: U ore 40,000 tons at 0.28% $U_3O_8$; Cu-U ore 270,000 tons at 0.33% $U_3O_8$, 3.4% Cu. Other mineralization and the geology of the area are discussed. The Rum Jungle treatment plant was designed to process 200 tons U ore and 400 tons Cu ore per day. The crushing section is common to both circuits. Under the combined Development Agency contract, which ended on 6th January, 1963, deliveries of U oxide totaled 3,249,483 lb. Exploration of the area continues; in addition to radiometric and geochemical surveys, various geophysical methods are also used including slingram and turam electromagnetic, self potential, induced polarization, and gravity surveys. Australia's proven U reserves are inadequate to supply the country's predicted needs to the end of the century. Other U in Australia producers are discussed. (BBB)

## Oceanography

**19872** THE EFFECT OF TRADE-WIND AIR TRANSPORT ON WATER POLLUTION BY $^{90}Sr$ AND $^{137}Cs$ IN THE EQUATORIAL ATLANTIC. Yakovleva, G. V. (Khlopin Radium Inst., Leningrad). Oceanology, (USSR) (Engl. Transl.), 7: 480-3(1967).

The content of nuclear fission products in the lower layer of the atmosphere and fallout were investigated on the 15th cruise of the Research Vessel Mikhail Lomonosov. The artificial radioactivity of the air remained practically constant in the latitude range 40 to 50°N. The content of individual radionuclides in the air was as follows: $^{144}Ce$, $5.0 \times 10^{-14}$ Ci/m$^3$; $^{137}Cs$, $0.8 \times 10^{-14}$ Ci/m$^3$; $^{90}Sr$, $0.5 \times 10^{-14}$ Ci/m$^3$. The amount of radioactive fallout at the time was insignificant. A detailed account of atmospheric circulation over the Atlantic is given. With this, the activity of the nuclear fission products transported during 1964 from 25 to 30°N to the equator by the northeasterly trade winds may be estimated. In the course of half a year the northeasterly trade wind carries a volume of air approximately $10^{18}$ m$^3$ into the equatorial zone, which signifies fallout of the following amount of fission products in 1964: $^{144}Ce$, $5 \times 10^4$ Ci; $^{137}Cs$, $8 \times 10^3$ Ci, $^{90}Sr$, $5 \times 10^3$ Ci. It was established that $^{90}Sr$ and $^{137}Cs$ concentration in Atlantic surface waters between 10°N and 5°S in 1962 to 1964 was considerably greater than along adjacent latitudes. There are two possible causes. Influx of $^{90}Sr$ and $^{137}Cs$ with water masses brought to the equator from latitudes around 30°N by the equatorial current and airborne transport of radionuclides by the northeasterly trade winds and their fallout with rain in the equatorial trough. The volume of intensively mixed equatorial Atlantic water is $1.6 \times 10^{15}$ m$^3$. The northeasterly trade wind air transport therefore produced the following concentration of radionuclides in the surface water of the equatorial Atlantic in

1964: $^{144}Ce$, $3 \times 10^{-11}$ Ci/m$^3$ = 6 counts per min per 100 liters; $^{137}Cs$, $5 \times 10^{-12}$ Ci/m$^3$ = 1 count per min per 100 liters; $^{90}Sr$, $3 \times 10^{-12}$ Ci/m$^3$ = 0.6 counts per min per 100 liters. The contribution of northeasterly trade wind air transport to the specific radioactivity of equatorial waters is therefore negligibly small. The $^{90}Sr$ and $^{137}Cs$ fallout in the water of the equatorial Atlantic in 1962 and 1963 can also not have been the source of their high radioactivity. (BBB)

**19873** TOTAL $\beta$-ACTIVITY OF RECENT BOTTOM SEDIMENTS OF THE NORTHWEST AFRICAN SHELF. Senin, Yu. M.; Sherstnev, A. I. Oceanology (USSR) (Engl. Transl.), 7: 487-91 (1967).

Total $\beta$-activity was determined in 96 bottom grab samples from fisheries areas on the northwest African shelf between 28 and 8°N and in the Gulf of Guinea around Takoradi. In addition to $\beta$-activity, the particle-size composition of the sediments was investigated, and the amounts of calcium carbonate, organic C, P, authigenous Si, Fe, and Mn were determined in some samples. The shelf sediments from regions of sedimentary rocks (between Cape Hubi and the port of Freetown) have lesser indices of activity than the shelf sediments of regions of metamorphic and igneous rocks (Gulf of Guinea). The main explanation for this difference is the different activity of the sedimentary and igneous rocks of the coast, and also that the igneous rocks occur in the humid tropical zone. The relation between the $\beta$-activity of the sediments and their particle-size composition and the increase in this relation as the dispersion of the sediments decreases are indicated: sand, 3.06 pCi/kg; fine silt, 7.60 pCi/kg (mean values). The increase of $\beta$-activity from sand to silt is related to a rise in the adsorption capacity of sediments of this series and to the increased content of fine particles. The increase may also be caused by changes in the mineralogical and general composition of the sediments. The relation between the activity of sediments and their chemical composition is considered taking as an example $CaCO_3$ and $C_{org}$. In fact, $\beta$-activity does not vary in the sequence: terrigenous–heavily calcareous sediments; some difference is to be noted only in sand. Within each particle-size type of bottom sediment radioactivity values are dependent on $C_{org}$ content. Calcareous sands have higher indices of activity than terrigenous sands. Moreover, particles of organic origin contain more then $^{40}K$. A different pattern is to be noted in fine silt and ooze; there is no evident dependence of $\beta$-activity on $C_{org}$ content. (BBB)

## Seismology

**19874** (NVO-1163-165) MODELS FOR CALCULATING CLOSE-IN MOTIONS FROM UNDERGROUND NUCLEAR EXPLOSIONS. Beaudet, P. R.; Cassity, C. R.; Davis, A. H.; deCaprariis, P. P. (Environmental Research Corp., Alexandria, Va.). Mar. 10, 1969. Contract AT(29-2)-1163. 54p. Dep. CFSTI.

Basic physical principles and mechanics have been used to construct one- and two-dimensional models of underground nuclear explosions. Recent advances, made by including the effects of plastic-brittle failure and permanent deformation in the one-dimensional model, are outlined. A brief review of the results obtained to date with both one- and two-dimensional models is given, followed by a summary and recommendations for future development of these programs. (auth)

# ENGINEERING

## Nuclear Explosions

*Refer also to abstracts 19874 and 19897.*

**19875** (PNE-903-F) LONG-RANGE AIRBLAST. Project PALANQUIN. Reed, Jack W. (Sandia Labs., Albuquerque, N. Mex.). Apr. 25, 1969. 44p. Dep. CFSTI.

Eight microbarograph stations measured the airborne acoustic wave from Palanquin. By use of the high-explosive calibration shots fired close in time and space to the nuclear cratering event, the airblast transmissivity for this underground burst was determined to be 0.026. Rocket and rawinsonde upper air observations were used to calculate acoustic wave paths, times, and propagated amplitudes for comparison with observations. Some problems in correlation were encountered which could not be completely resolved, but a good general exercise in verification was allowed. (auth)

**19876** (TID-3522(8th Rev.)(Suppl.1)) A SELECTED, ANNOTATED BIBLIOGRAPHY OF THE CIVIL, INDUSTRIAL, AND SCIENTIFIC USES FOR NUCLEAR EXPLOSIVES. West, Robert G. (comp.) (Division of Peaceful Nuclear Explosives (AEC), Washington, D. C.); Kelly, Robert C. (comp.) (Division of Technical Information Extension (AEC), Oak Ridge, Tenn.). Apr. 1969. 43p. Dep. CFSTI.

This supplement to TID-3522(8th Rev.) contains 265 annotated references to reports and published literature on the USAEC's Plowshare Program. The references are arranged by subject category. Report Number and Availability, Film and Tape, Author, and Experiment Indexes are included. (auth)

## Facilities and Equipment

*Refer also to abstracts 19896, 20478, 20822, 20823, 20832, 20843–20845, 20861–20863, 21206, 21586, and 21591.*

**19877** (BNL-13311) ANALYSIS OF MULTI-DIMENSIONAL THERMOELASTIC DYNAMIC RESPONSE OF REACTOR FUEL ELEMENTS. Reich, Morris (Brookhaven National Lab., Upton, N. Y.); Koplik, Bernard (Polytechnic Inst. of Brooklyn, N. Y.). Nov. 1968. 69p. Dep. CFSTI.

A detailed finite difference method for determining the dynamic response of pulsed reactor fuel elements that is based on the exact theory of elasticity is described. The advantage of this method is that the numerical solution can describe approximately any elastic wave propagation problem from a semi-infinite bar to a thin circular plate. (F.S.)

**19878** (NLCO-1026) EFFECTS OF POURING ORIFICE AND MOLD BOTTOM CONFIGURATION ON INGOT SURFACES. Graman, G. A.; Kettler, D. E. (National Lead Co. of Ohio, Cincinnati). Mar. 1969. Contract AT(30-1)-1156. 19p. Dep. CFSTI.

A laboratory-scale study was conducted to determine the effect of orifice configuration on the integrity of a pour stream simulating molten uranium. The effect of the mold bottom shape on the initial metal splash was also investigated. The apparatus used consisted of a $\frac{3}{8}$-scale acrylic plastic model of the bottom-pouring crucible and mold used in production. Mercury was used as the fluid in these studies because many of its physical properties are similar to those of molten uranium. The changes in the pour stream and in the initial metal splash were recorded with a motion picture camera. It was found that pour plugs having an orifice with tapered sidewalls and a rounded edge at the top produced the most desirable pour stream. Mold bottoms which were flat or which approached flatness with no abrupt change in contour minimized metal splash. (auth)

**19879** (NP-17799) STATUS OF PETITIONS FOR IRRADIATED FOODS AND PACKAGING MATERIALS. Deitch, Jerome (Business and Defense Services Administration, Washington, D. C.). Apr. 1968. 13p.

A summary is given of the status of irradiated food petitions to the U. S. Food and Drug Administration (FDA) and to the U. S. Department of Agriculture Technical Services Division. Food items and packaging materials which have been approved, those pending approval, and those scheduled for submission during the period 1968 to 1972 are listed. References to FDA petition requirements and regulations are included in the final section. (auth)

**19880** (RD/B/N-1209) FINITE ELEMENT STRESS ANALYSIS OF PLANE AND AXISYMMETRIC STRUCTURES. Campbell, J. S. (Central Electricity Generating Board, Berkeley (England). Berkeley Nuclear Labs.). Jan. 1969. 24p. Dep.

Detailed finite element methods are described which are applicable to the stress analysis of plane and axisymmetric structures. The four conditions considered are plane stress, mathematical plane strain (axial strain zero), engineering plane strain (axial strain constant but not zero), and axisymmetric stress. The computer programs FEP and FEX are based on the theory described. (auth)

**19881** ON THE METHOD OF EARTHQUAKE-PROOF DESIGN FOR PIPING SYSTEMS. Yamamuro, Makoto; Kurokochi, Teruo. Chubu Denryoku K. K. Kenkyu Shiryo, No. 42, 104-21 (Dec. 1968). (In Japanese).

Earthquake-proof design of steam power stations of large output and nuclear power stations is discussed. When piping for the primary cooling system of a nuclear power station is damaged by earthquake, a radiation hazard is feared. Vibration measurements and model tests, were made for a large piping system in a newly constructed steam power plant. In 1962 and 1963, the Society of Mechanical Engineers developed the theoretical calculation method of vibration mode for piping systems and the calculation method of response to earthquake in the building–installation system. In the earthquake-proof design for piping systems, many problems such as the vibration characteristics of piping, the response calculation, and measures to reduce vibration must be solved. The transition matrix method was used as the main tool and is explained. The preliminary test and the calculation to determine the piping model for research of earthquake-proof construction are described. In case of an earthquake the piping is expected to oscillate as much as 20 cm, therefore, the part of the piping penetrating each floor must be sufficiently secured. A travel of about 15 cm in the damper, the oscillation-preventing device, is estimated to be adequate. (NSA of Japan)

**19882** DEVICE FOR ADDING NEGATIVE IONS IN AN AIR-CONDITIONING UNIT. Ashahina, Jiro. Japanese Patent 1968-22273. Sept. 24, 1968. Filed Dec. 30, 1963.

The advantages of the method proposed are: simple construction, readily applicable to installed air-conditioning units; high safety and low cost, and efficient emission of negative ions. A series of narrow plates whose top is bent are installed at the outlet of an air-conditioning unit. At the base of each plate is attached a radioactive substance by which the incoming air is ionized. An electrified member having negative static charge is attached to the bent top of the plate, to collect the positive ions. (NSA of Japan)

**19883** METHODS AND APPARATUS RELATING TO SEALED ENCLOSURES. Trexler, Philip Charles (to Snyder Mfg. Co., Inc.). British Patent 1,146,767. Mar. 26, 1969. Filed Jan. 5, 1967.

Reference is made to means for establishing and maintaining an uncontaminated and controlled environment within an enclosure, while at the same time permitting entry into the enclosure. An isolating means is described which comprises a first enclosure having an access port with a severable membrane seal; a second enclosure is positioned adjacent to the first enclosure and has an access opening with a similar severable membrane. Means are provided for securing the membranes in adjacent opposing relationship and providing a seal around the space between the membranes; means are also provided for introducing a decontaminating substance. The arrangement is such that the membranes can be severed to permit access between the enclosures through the space, while maintaining the enclosures sealed from the surrounding atmosphere. Means are provided for withdrawing the decontaminating substance from the space, and also for evacuating the space. A number of variants of the system are described, together with methods of operation. (UK)

**19884** GAMMA-IRRADIATION EQUIPMENT FOR BIOLOGICAL STUDY. Imai, Takeshi; Tsuzuki, Tadaichi (Tokyo Shibaura Electric Co., Kawasaki, Japan). Toshiba Rebyu, 24: 216-22(Feb. 1969). (In Japanese).

Radiations from radioisotopes have contributed much to technology, medical science, chemistry, biology, etc. They are indispensable especially to the study of the heredity of creatures. Gamma-irradiation equipment for biological study is discussed according to the purpose as follows: (1) unit type, (2) gamma-room type, (3) gamma-green-house type, (4) gamma-field type, and (5) gamma-room type with irradiation-conditions controller. (NSA of Japan)

**19885** HOLE-MEASURING DEVICES. Janko, Ambrus; Jones, Graham Henry (to English Electric Co., Ltd.). British Patent 1,146,677. Mar. 26, 1969. Filed Sept. 28, 1965.

Reference is made to devices for gaging the straightness of an elongated hole or passage, and for measuring the degree of interference between such a hole or passage and a long inserted body. The device described comprises a body which can be moved along the hole or passage, with three measuring units arranged one at each end of the body and one at the middle, each such unit having feeler means extendable laterally from the body, together with recording means. Such a device may be employed as a gage rod for detecting interference between a nuclear reactor control rod and its channel. (UK)

**19886** RADIATION IMMUNOLOGY INCUBATOR (Engineering Materials). (Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant). (CAPE-1841).

20 drawings.

An incubator is described in which close control must be maintained on the temperature, humidity, and pH of the atmosphere. The atmosphere is maintained at the desired pH by controlling the $CO_2$ content. The relative humidity of the circulating air is controlled to ±2% by an on-off controller labeled "Wet Bulb." The Wet Bulb controller is set by an electrohygrometer. (For details see TID-4100, Suppl. 51). (F.S.)

**19887** ELECTRON-RAY IRRADIATION DEVICE. Aihara, Ryuzo (to Sumitomo Electric Industry Ltd.). Japanese Patent 1968-26678. Nov. 15, 1968. Filed Apr. 18, 1964.

An irradiation device is described for irradiating a moving material with electrons, where the movement of the material and the electron current of an electron accelerator are in a state of proportion to each other to reduce the nonuniformity of irradiation. The condition of electron acceleration and the scanning are kept constant. The rate of movement of the irradiation material is detected, and a device for giving a particular electron current, which is set at the desired electron dose, is used. Thus the movement of the material and the electron current are brought into a state of proportion to obtain the desired uniformity of the electron irradiation. (NSA of Japan)

**19888** THERAPEUTIC DEVICE USING A RADIOISOTOPE. Suzuki, Hirotsugu (to Tokyo Shibaura Electric Co., Ltd.). Japanese Patent 1968-27700. Nov. 29, 1968. Filed Nov. 26, 1965.

A method is proposed whereby the drawbacks to conventional similar devices can be eliminated including complete shielding, easy exchange of the light-source lamps, and elimination of the deterioration of an optical system. The device consists of a large shielding mass in which a horizontal long hollow is cut from one end and halfway in the hollow length a downward irradiation hole is cut connecting to the hollow; a horizontally rotating disc, located in the deeper half of the hollow, with a radiation-source containing chamber cut at one end in the bottom and with a light-reflecting mirror containing chamber cut similarly at the other end; a rotating disc, located in the shallower half of the hollow, with a horizontal penetrating hole to connect to the mirror chamber; and a light-source lamp, located just outside the exit of the hollow. Either of the two chambers can engage to the irradiation hole. By this construction and mechanism, the irradiation-field aiming and the irradiation can be done appropriately. (NSA of Japan)

**19889** CONTROLLABLE IRRADIATION DEVICE. Smith, Gordon R. (to Minnesota Mining and Mfg. Co.). U. S. Patent 3,426,206. Feb. 4, 1969. Filed Sept. 13, 1965.

Means for varying and controlling the intensity of radioactive emission directed toward a target area, in which a mixture of radioactive particles and a nonradioactive liquid is discriminately agitated to maintain the particles suspended in a first portion of the liquid and not in a second portion is described. The particles and liquid drawn from the first portion and the clear liquid drawn from the second portion are selectively blended to achieve the desired intensity level and then directed to a tubing array in the vicinity of the target to be irradiated. (Offic. Gaz.)

**19890** PREFABRICATED RADIATION SAFE WINDOW ADJUSTABLE FOR MOUNTING IN BIOLOGICAL SHIELDS OF DIFFERENT THICKNESSES. Nelson, Wilfred W. U. S. Patent 3,433,957. Mar. 18, 1969. Filed Oct. 14, 1965.

A prefabricated radiation safe window is described which is adjustable to permit its incorporation into biological shields of different sizes. The window includes a casement having a raised window jamb and an outwardly flared encircling apron structure extending from one side of the casement for overlapping relationship with a biological shield wall into which the window is to be mounted. Radiation absorbing material such as lead extends from the inner periphery of the casement and along the outwardly flared portion to provide a continuous absorbing structure from the shield wall to the window opening in the casement. Spaced anchor grooves are provided along the inside periphery of the casement and pane retainer spring clips are adapted to cooperate with the grooves to permit radiation absorbing window panes of different thicknesses to be secured within the casing. A rim member is telescopically mated with the casement on the side opposite the apron structure so that the frame can be mounted in biological shields of different thicknesses. (Offic. Gaz.)

**19891** METHOD FOR MEASURING DEPTH OF TOP PLUG IN WELL CASING CEMENTING. Sutton, Ralph O. U. S. Patent 3,426,204. Feb. 4, 1969. Filed July 15, 1965.

A method of measuring the relative position of the top of a cementitious settable material which has been pumped downwardly within a well casing. The relative depth of the top of the cementitious material is determined by inserting a preformed top plug into the well casing and forcing the plug downwardly within the casing, and thus forcing the cementitious settable material ahead of the preformed top plug. A radiation detector, is moved downwardly within the well casing to continuously monitor the relative depth of the plug which is provided with a radiation emitting material. In a preferred embodiment the preformed top plug is formed of a drillable material and to avoid contamination of the well the radiation emitting material in the plug is chosen to have a half-life of approximately the time necessary to permit the initial curing of the cementitious material. (Offic. Gaz.)

**19892** IMPROVEMENTS IN OR RELATING TO ELECTRIC ARC WELDING TORCHES. Sherwood, Eric Arthur (to United Kingdom Atomic Energy Authority). British Patent 1,145,252. Mar. 12, 1969. Filed June 17, 1965.

Reference is made to torches of the type designed to make annular welds in the internal bore of pipes and in other places difficult of access. Previous designs have used long nonconsumable electrodes which can be inserted down the pipe bore for the required distance and rotated on the pipe axis. This arrangement necessitates using a long unsupported length of refractory electrode rod rotated from one supported end and presenting difficulty in use in that the locus of the electrode tip is liable to be eccentric to the axis of rotation of the holder. Long lengths of expensive electrode material are also required. The improved torch which is described comprises a tubular electrode holder arranged to conduct current and shielding gas to a welding electrode mounted near one end of the holder so as to project laterally and retained in position by a resiliently mounted rod with clearance within the tubular electrode holder. The torch is designed to make annular welds in the internal bore of pipes. (UK)

**19893** GAS SEALS. Tisdall, Derek Edmond (to Darchem Engineering Ltd.). British Patent 1,144,976. Mar. 12, 1969. Filed Mar. 21, 1967.

A gas seal system is described for use in vessels such as nuclear reactors, etc. In a nuclear reactor the seal has to be made without significantly reducing the efficiency of the heat insulation of the reactor vessel from hot gases seeping into the insulation. An object of the described system is to provide a gas seal that will withstand a steady and cyclic pressure difference of up to 5 psi with only a small and acceptable leakage rate, and will withstand both steady and cyclic temperature gradients of 400°C or more, across a width of 2 inches. Another object is to provide a seal tolerant of imperfections in the vessel structure to which it is attached, and for which erection is relatively simple using a weld design which can readily be checked for integrity. The seal is disposed between the wall thermal insulation of a chamber and a projecting support member within the chamber. It comprises a flat plate in contact with a frame mounted on the wall of the chamber at one side and freely supported on the support member at the other side. The plate has a corrugated foil and is secured to the frame in a gas-tight manner. One plate and two foils are preferably used, but a labyrinth seal may be built up by using additional plates with or without additional foils. (UK)

**19894** $^{192}$Ir, GAMMA MED, A NEW RADIATION INSTRUMENT FOR LOCALIZED BRACHYTHERAPY OF BRAIN TUMORS. Mundinger, F. (Univ., Freiburg i. B.). Acta Neurochir., 16: 313-14 (1967). (In German).

Rechargeable equipment that facilitates reaching a high necrosis dose in a tumor within a few minutes is described. The $^{192}$Ir source of ~120 Ci is a cylinder of 1 mm dia and variable length, enclosed in a monel metal casing. The source is located centrally within a heavy metal ellipsoid. The shielded holder weighs ~30 kg and is located in a protective, movable housing. The $^{192}$Ir source is fastened to a flexible cable and is controlled remotely. It can be introduced into the implanted tubule within 2.5 sec. After the

required dose is delivered the source is withdrawn into its rest position. A built-in radiation detector signals the proper return of the source. The physical arrangement of multiple tubules for preplanned irradiations is described. Malignant tumors, such as glioblastomas have been treated successfully with the equipment, which is suitable for treatment of tumors of the larynx, bronchi, bladder, prostate, cervix, and uterus if specially designed applicators are used. (BBB)

## Heat Transfer and Fluid Flow

*Refer also to abstracts 21476, 21478, 21487–21492, and 21554.*

**19895** (ORNL-TM-2445) POOL-BOILING CRITICAL HEAT FLUXES FOR NON-NEWTONIAN AQUEOUS SOLUTIONS OF POLYETHYLENE OXIDE. Gambill, W. R. (Oak Ridge National Lab., Tenn.). Dec. 9, 1968. Contract W-7405-eng-26. 36p. Dep. CFSTI.

Critical heat flux tests were conducted at atmospheric pressure with subcooled aqueous solutions of 0.01, 0.25, and 0.50 wt % Polyox (polyethylene oxide water-soluble resin) heated by a horizontal, 0.234-in.-OD, resistively heated, A-nickel tube. The critical heat fluxes were much smaller than those characteristic of water-cooled systems, but the critical wall superheats were generally larger. Twelve critical-flux correlations which have been proposed for the saturated-pool case were compared with the data extrapolated to zero subcooling; none showed satisfactory agreement. (auth)

**19896** (SAN-651-77) ORGANIC RANKINE CYCLE TECHNOLOGY PROGRAM. Quarterly Progress Report No. 11, October 1, 1968–January 1, 1969. Niggemann, R. E. (Sundstrand Aviation-Rockford, Ill.). Jan. 15, 1969. Contract AT(04-3)-651. 69p. Dep. CFSTI.

The investigation of the technology necessary to successfully develop an Organic Rankine Cycle power conversion system capable of long duration operation in a space environment was continued. The specific working fluids being evaluated are biphenyl and the eutectic mixture of biphenyl and biphenyl ether. The four main areas of investigation include: the pyrolytic degradation of the working fluids; the performance and stability of bearings operating in the eutectic mixture; evaluation of small high speed condensate pumps operating at high suction specific speeds with the eutectic mixture; and the heat transfer, performance characteristics, and stability of organic working fluid boilers. After 5377 hours of operation in the working fluid investigation, the eutectic continued to show excellent stability at 700°F and a projected degradation rate of 0.057% as compared with 0.133% for biphenyl. The tilt pad bearing tests showed very little wear after 54 cycles. The pump test rig was operated, and the effects of impeller-to-housing clearance on pump efficiency were determined. More heat transfer data for the boiler loop was obtained, and tests were conducted to determine the effects of a flashing orifice on the stability of boiler operation. (L.C.L.)

**19897** (SC-TM-69-120) VENTING OF A HIGH-ENTHALPY GAS FROM AN UNDERGROUND CAVITY THROUGH A VERTICAL HOLE ONE-HALF MILE LONG. Reis, George E.; Russo, Anthony J. (Sandia Labs., Albuquerque, N. Mex.). Mar. 1969. 85p. Dep. CFSTI.

The flow characteristics of the hot, high-pressure products of a methane-oxygen combustion exhausting from a large, spherical, underground cavity through a ½-mile-long hole were calculated. The results are presented in tabular form. (auth)

**19898** INVESTIGATIONS ON THE CAVITATION THRESHOLD OF WATER BY FAST NEUTRONS. Kuhn, Dietmar (Oesterreichische Physikalische Gesellschaft, Innsbruck). Acta Phys. Austr., 27: 23-30(1968). (In German).

The cavitation threshold was measured as a function of the air content of water, since the cavitation threshold usually strongly depends on the gas content of a liquid and it is to be expected that the gas content would be affected by a radiochemical process. The experimental results showed that fast neutron irradiation causes a sharp decrease of the threshold with decreasing air content. This decrease is shown to be the consequences of a radiochemical process in which the oxygen constituent of the air reduces the concentration of free radicals, although the oxygen concentration itself remains unaltered. (J.S.R.)

**19899** IMPROVEMENTS RELATING TO THERMAL INSULATION. Bucknell, Ronald Ernest (to Whessoe Ltd.). British Patent 1,145,249. Mar. 12, 1969. Filed Apr. 14, 1967.

An improved system of heat insulation is described for use in nuclear reactors (and nonnuclear vessels), and particularly in conjunction with gas or vapor phase operations, the materials employed are chosen so as to be acceptable for the conditions of operation. The inner side of the wall of the vessel to be insulated is provided with insulation which includes at least one layer of nonmetallic material, the outer part of this layer being composed of fibrous material, with at least one layer of metallic or other sheet material applied on the inner side of the insulating layer. The insulation may consist of a plurality of layers of metal foil arranged alternately with a plurality of layers of fibrous inorganic material, which may be nonwoven mat or board or woven material. Part of the fibrous material may be replaced by blocks of solid insulant, which may be porous or nonporous. In order to reduce convection currents within the layer of insulation material gas seals may be provided in a manner described. Means of securing the insulating material in position are described. (UK)

## Isotope Technology

*Refer also to abstract 21609.*

**19900** (AAEC/TM-486) DIFFCO: A COMPUTER CODE FOR CALCULATING DIFFUSION COEFFICIENTS. Kelly, J. W. (Australian Atomic Energy Commission Research Establishment, Lucas Heights). Dec. 1968. 11p. Dep.

DIFFCO evaluates the diffusion coefficient D from data obtained using the fraction-remaining method for tracer volume diffusion from a thin layer source into a semi-infinite solid. Absorption and decay corrections are assumed negligible. The program is written for an IBM360 computer and uses H-level Fortran. (auth)

**19901** (AD-670212) FEASIBILITY STUDY AND CONCEPTUAL DESIGN FOR A PERSONAL THERMAL CONDITIONING SYSTEM. Technical Report, August–December 1967. Sullivan, J. J.; Disco, N. R.; Wong, A. (Sanders Nuclear Corp., Nashua, N. H.). Contract F41609-67-C-0096. 327p. (AMD-TR-68-1). CFSTI.

An airman forced to eject over Arctic terrain or cold water is faced with a very brief survival period after landing. (Approximately three minutes in 28°F water.) This period of time is insufficient to initiate and accomplish a successful rescue mission. A study has been made to determine the feasibility of extending the survival period by warming the airman with heat generated by a radioisotope. A conceptual design has been created consisting of a network of water filled tubes worn beneath an insulated suit. Water in the tubes is heated by a 500 watt radioisotope to warm the pilot during a survival situation (28°F water or −65°F air), and is cooled by an 825 watt refrigerator to keep the airman comfortable while flying the aircraft with cabin temperatures up to 120°F. A thermoelectric power generator supplies 12 watts of power for the water pump. Comparison studies of several radioisotopes have been made. System calculations and component calculations show that the concept is feasible and practicable for extending the survival period indefinitely. The survival system weight is estimated at 80 pounds and is configured to fit in a USAF standard ejection seat kit. (auth) (USGRDR)

**19902** (BNL-50132) BIBLIOGRAPHY OF TECHNICAL PUBLICATIONS AND REPORTS OF THE RADIATION DIVISION, BROOKHAVEN NATIONAL LABORATORY, JULY 1965–JUNE 1968 INCLUSIVE. Metz, D. J.; Kopp, L. E. (Brookhaven National Lab., Upton, N. Y.). Jan. 1969. 4p. Dep. CFSTI.

A listing of technical publications and reports issued by the BNL Radiation Division from July 1965 through June 1968, is presented. References to reports and published literature on radiation source technology and dosimetry, applied radiation and chemonuclear technology, and basic and exploratory research are included. (J.C.W.)

**19903** (DP-1192-1) SAVANNAH RIVER LABORATORY ISOTOPIC POWER AND HEAT SOURCES. PART I. $^{60}$Co. Quarterly Progress Report, October–December 1968. Hilborn, H. S. (comp.) (Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.). Feb. 1969. Contract AT(07-2)-1. 19p. Dep. CFSTI.

Preliminary (theoretical) analyses indicated that CoO and CoO–MgO solid solutions are promising high temperature fuel forms of $^{60}$Co. Extrapolation of stress-rupture data from the literature indicated that superalloy capsules will perform satisfactorily for 5 years at 1000°C or higher. Haynes 25 had the highest long-term strength of the materials tested. Satisfactory performance of an inactive Inconel 600 capsule at 1000°C for 10,000 hr (1.14 yr) was confirmed by destructive examination. More internal reaction than expected was revealed by destructive examination of two active capsules after 10,000 hr at 900°C. (auth)

**19904** (KFK-853) PRINCIPLES AND ECONOMIC ASPECTS OF THE SEPARATION NOZZLE PROCESS. Becker, E. W.; Bier, W.; Schuette, R. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Kernverfahrenstechnik). Oct. 1968. 13p. (CONF-681015-2). Dep.

From Symposium on Problems Bearing on Isotope Separation of Uranium, Turin, Italy.

A process for enriching $^{235}U$, based on pressure diffusion in supersonic jets, is described. A mixture of 5 mole % $UF_6$ and 95 mole % He is expanded through a slit-shaped nozzle. Deflection of the jet by curved walls results in a partial spatial separation of the components; the gas moving close to the deflecting wall becoming enriched in $^{238}U$, while $^{235}U$ accumulates in the remaining fraction. Economic aspects of the process are considered. (M.C.G.)

**19905** (KFK-854) OPERATION OF A 10-STAGE SEPARATION NOZZLE PILOT PLANT. Becker, E. W.; Frey, G.; Schuette, R.; Seidel, D. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Kernverfahrenstechnik). Oct. 1968. 13p. (CONF-681015-3). Dep.

From Symposium on Problems Bearing on Isotope Separation of Uranium, Turin, Italy.

A computer analysis of the steady-state and transient behavior of a small separation nozzle cascade indicated that the system was inherently stable. Therefore, the pilot plant was constructed without any automatic control installations. Equipment design and arrangement for the plant are discussed. Plant operation was stable with an overall enrichment factor of 1.082. (M.C.G.)

**19906** (MMM-3691-44) SNAP-21 PROGRAM, PHASE II. DEEP SEA RADIOISOTOPE-FUELED THERMOELECTRIC GENERATOR POWER SUPPLY SYSTEM. Quarterly Report No. 10, October 1–December 31, 1968. (Minnesota Mining and Mfg. Co., St. Paul. Electrical Products Group). Contract AT(30-1)-3691. 126p. Dep. CFSTI.

EQUIPMENT AND PROCEDURES — testing and performance of SNAP-21 power conditioning
FUEL CAPSULES — testing of SNAP-21, ultrasonic method for
MATERIALS TESTING — equipment and methods for SNAP-21 thermoelectric generator components
SHIELDING — fabrication and testing of SNAP-21 biological
SYSTEMS FOR NUCLEAR AUXILIARY POWER (SNAP-21) — thermoelectric generators for, assembly, operation, and testing of 10 W
THERMAL INSULATION — assembly and testing of SNAP-21
THERMOCOUPLES — testing and performance of SNAP-21
THERMOELECTRIC CELLS — fabrication, testing, and performance of 10 W SNAP-21 (R.C.K.)

**19907** (ORO-668) SELECTED BACKGROUND INFORMATION ON URANIUM ENRICHING. (Atomic Energy Commission, Washington, D. C.). Mar. 1969. 56p. DTIE Free.

The seven separate steps of the nuclear fuel cycle (mining and milling, $UF_6$ conversion, enrichment, fabrication, irradiation, shipping, and reprocessing) are discussed. Typical cost experience for each step is included, with special emphasis placed on the enrichment step and its relation to the over-all fuel cycle. A description of gaseous diffusion plants is presented, including options and costs for increasing uranium enrichment capabilities. Current and long-term operational planning for optimization of power procurement, plant improvements, new plant additions, and level of preproduction are presented. Estimates are given of costs for operation of existing gaseous diffusion plants and capital investments for process improvements to the plants and construction of new plants. (M.C.G.)

**19908** (ORO-3224-14) X-RAY ANALYSIS USING RADIOISOTOPE SOURCES. Final Report. Rhodes, J. R. (Texas Nuclear Corp., Austin). Sept. 25, 1968. Contract AT(40-1)-3224. 127p. Dep. CFSTI.

Studies from 1964 to 1966 on characteristic x-ray excitation techniques for light elements are reviewed. Later work (1966 to 1968) including the development of a portable radioisotope x-ray analyzer and its field evaluation for some 50 different determinations is examined. Research into heterogeneity effects and into factors leading to improved sensitivity in x-ray fluorescence analysis was conducted and a new measurement of the energy of the 88 keV $^{109}Cd$ gamma ray was made. (auth)

**19909** THE MANIPULATION AND USE OF THE ATOMIC NUCLEUS. II. PRACTICAL APPLICATIONS OF RADIOISOTOPES. Kostikov, Lev. Impact Sci. Soc., 18: 43-9(1968).

Use of radioisotopes, especially in the USSR, is reviewed with respect to agriculture, biology, medicine, and chemistry. In one application in the USSR, the irradiation of seeds before sowing, results show that the yields of cabbage crops are increased by 5 to 10%, cucumbers by 15 to 30%, tomatoes by 10 to 15%, carrots by 25 to 30%, and radishes by 6 to 11%. Calculations by the Institute of Economics of the USSR Academy of Sciences indicate that if only a quarter of the area under these crops were to be sown with irradiated seeds, an extra 100,000 to 200,000 metric tons of vegetables would be produced. The higher yields would not only offset the comparatively small irradiation costs but save 15 to 30 million rubles a year by lowering production costs. Hen eggs when exposed to very small doses of $\gamma$ radiation show a 3.5% increase in the number that hatch; moreover, the egglaying rate of hens hatched from such eggs increases by 12 to 17%. How radioactivity can affect chemical reactions and chemical processes is considered. For example, irradiated polyethylene has a number of mechanical properties superior to those of the nonirradiated material. How the radioisotopes used in radiation chemistry or in experimental industrial plants are obtained is also discussed: either by subjecting stable elements to neutron radiation in the reactor, thus inducing radioactivity; or by processing used uranium reactor fuel. (BBB)

**19910** COHERENT GAMMA RAY EMITTER. Eerkens, Jozef W. (to Terra Nova Inc.). U. S. Patent 3,430,046. Feb. 25, 1969. Filed June 23, 1966.

An emitter for coherent gamma rays comprising an elongated rod of a length-to-diameter ratio in excess of five and preferably between ten and twenty, containing a radioactive isotope of the Moessbauer type is described. The rod is cooled below the temperature above which the Moessbauer effect therein is substantially suppressed to secure a stimulated emission of gamma rays within the rod and progressive multiplication of gamma rays along the axis of the rod to emit substantially superradiant, directionally coherent gamma rays from an end of the rod. An oscillating magnetic field may be applied axially of the rod at a radio frequency to bring the interaction between an excited nucleus and a conversion electron into substantial resonance to enhance the deexcitation rate between energy states of the excited nucleus and to introduce at least radio frequency time coherence into the emitted gamma ray beam. Means are disclosed to apply a steady magnetic field transversely to the axis of the rod to orient the nuclei of the radioisotope and cause the gamma rays to be emitted in preferred directions perpendicular to the direction of the field thereby securing a gain in directional coherence of the emission along the axis of the rod. Instead of the oscillating magnetic field the decay rate of the radioisotope may be controlled by the application of monochromatic ultrasonic waves or an electromagnetic beam of a wavelength to bring the internal conversion process of excited nuclei into a resonant condition, the electromagnetic beam being generated by a laser or a microwave generator. Modulation of the various control means for the decay rate of the radioisotope effects modulation of the emitted gamma ray beam. (Offic. Gaz.)

**19911** RADIATION DIAPHRAGM. Furuya, Masamichi (to Tokyo Shibaura Electric Co., Ltd.). Japanese Patent 1968-29663. Dec. 5, 1968. Filed Apr. 28, 1966.

The radiation diaphragm proposed is used, especially for medical x or gamma rays, to define the irradiation field. The radiation diaphragm consists of the following: a radiation source; a pair of two oblong blocks arranged parallel to each other ahead of the source; another pair of similar blocks located in front of the first pair oriented at right angles to the first pair; and a rack-and-pinion device installed for each pair which moves the oblong blocks in a circle around the source thus acting as a collimator. (NSA of Japan)

**19912** POWERPLANT HAVING A RADIOACTIVE HEAT SOURCE. Wagle, Joseph A. (to General Motors Corp.). U. S. Patent 3,435,617. Apr. 1, 1969. Filed Apr. 6, 1966.

A powerplant that includes a boiler heated by decay of a radioactive material, a turbine, a condenser, a feed water pump, and a generator driven by the turbine is described. A relief valve causes the boiler to accumulate steam and then releases it through a constant-pressure regulating valve to the turbine until the boiler pressure is reduced to relief valve closing pressure, which is significantly lower than the opening pressure. The turbine is thus operated intermittently at constant pressure. (Offic. Gaz.)

**19913** GAMMA-IRRADIATION PLANTS UTILIZING REACTOR FUEL ELEMENTS. PART I. Suckow, W. (Zentralinstitut fuer Kernforschung, Rossendorf, Ger.). Isotopenpraxis, 5: 1-10(Jan. 1969). (In German).

Topics discussed include physical properties; the historical development of irradiation plants utilizing reactor fuel elements; and technological characteristics of the fuel element plants. (auth)

## Materials Testing

*Refer also to abstracts 20028, 20499, and 21592.*

**19914** (BNWL-996) MISCELLANEOUS EDDY CURRENT TECHNIQUES. Libby, H. L. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Jan. 1969. Contract AT(45-1)-1830. 23p. Dep. CFSTI.

Several eddy current test techniques which are being developed are discussed. These techniques include controlling the curvature of test coil impedance lift-off loci and stabilizing the temperature of eddy current test coils. An eddy current ultrasonic transducer and the impedance relationship of a solenoid encircling a bar are described. The flow direction of eddy currents in liquid Wood's metal is discussed and an operational test for phase detectors is explained. (F.S.)

**19915** (TID-24896) GLOVEBOX WINDOW MATERIALS. A GLOVEBOX FIRE SAFETY APPLICATION. (Factory Mutual Research Corp., Norwood, Mass.). 1969. 35p. Dep. CFSTI.

An investigation of fire protection and operating requirements for glovebox window materials is described. A literature search was conducted, AEC sites visited, and users of gloveboxes interviewed to identify the problems associated with window materials. Selection criteria were established and tests conducted on various glass and plastic materials, including most of those currently in use at AEC sites. Of the 17 different window materials tested, none was found to be ideal. The glasses lacked impact resistance, were etched by fluorides, and were brittle, while the plastics were flammable in various degrees and were easily scratched. A ranking was established, nevertheless, for the more promising window materials: wired glass, laminated glass, and polycarbonate. (auth)

**19916** DEVELOPMENTS IN NONDESTRUCTIVE MEASUREMENT. Kaines, C. J.; Preece, K. N. (Morganite Research and Development Ltd., London). Instrum. Pract., 23: 205-9 (Mar. 1969).

Some developments in nondestructive measurement which are being applied to process control and development are described. These involve ultrasonic scanning flaw detection using roller probes, density measurement based on gamma absorption, and the examination of voids by gamma scanning. (auth)

**19917** ULTRASONIC SPHERE INSPECTION FIXTURE (Engineering Materials). (California Univ., Livermore. Lawrence Radiation Lab.). (CAPE-1850).

63 drawings.

An ultrasonic device is described for inspecting welds and/or the parent materials in spheres. The part to be inspected is mounted between 2 vertical chucks. The ultrasonic transducer is rotated radially about the sphere. Acoustic coupling is provided by a bubbler water column built into the transducer holder. Water is supplied to the column by means of a recirculating pump Longitudinal or shear waves can be introduced into the sphere by selecting the transducer holder which positions the transducer at the appropriate incident angle. The device is operated in conjunction with a helical C-scan recorder. (For details see TID-4100, Suppl. 51). (F.S.)

**19918** DEVICE FOR NEUTRON RADIOGRAPHY. Ogawa, Kazuyuki (to Tokyo Shibaura Electric Co., Ltd.). Japanese Patent 1968-25759. Nov. 6, 1968. Filed Apr. 30, 1965.

A method is proposed whereby the condition of resolution and of thermal neutron intensity can be easily adjusted to obtain optimal photography. The device consists of a neutron source, such as a nuclear reactor; a horizontal collimator hole (through a shield); a neutron-scattering body which plugs the hole midway but movable through the hole; a subject for neutron radiography set just outside the exit of the collimator hole; and the photographic film located next to the subject. By moving the scattering body relative to the position of a subject, the resolution and the neutron intensity can be changed to obtain the desired maximal photography. (NSA of Japan)

## Protective Structures

*Refer also to abstract 20975.*

**19919** (CONF-680507-, pp 393-7) PROTECTION OF HOSPITALS IN CASE OF NUCLEAR FALLOUT. Bull, Arne O. (Oslo Univ. (Norway)).

A Norwegian committee is working on the problems of protecting hospitals against wartime hazards and damages. Some preliminary conclusions made as to fallout hazards to hospitals are presented and some protective measures believed to be applicable are described. Special attention is paid to the survival phase and to protective measures that can be applied on short notice. Also countermeasures that reduce doses with small factors like 2 to 5 are of vital importance if doses are likely to reach critical levels. Some protective measures like shelter occupancy can seriously reduce hospital capacity and the medical caretaking causing human losses that has to be balanced against the risks from not using such measures or using them in a limited way. Also included are notes on hazards evaluation and choice of countermeasures, collection of information and means of communication, organization of hospital emergency groups, minimum desirable gamma protection factors, shelter occupancy administration, contamination control, evacuation of critically exposed hospitals and reoccupation problems. (auth)

**19920** (CONF-680507-, pp 541-55) STATUS OF FALLOUT SHIELDING CALCULATIONS IN THE USA. Eisenhauer, C. (National Bureau of Standards, Washington, D. C.).

Current estimates of the protection offered by buildings against fallout radiation in the U.S. are derived mainly from calculations devised by the U.S. Office of Civil Defense (OCD) and the U.S. National Bureau of Standards (NBS). These calculations are being constantly reviewed in light of more recent experiments and calculations with the intention of revising the calculational methods where necessary. The accuracy of the present calculations are discussed in general, and some of the areas in which the present calculations seem inadequate are detailed. Some attempt is made to determine the impact of uncertainties in the calculations on the US-OCD shelter program. First, a discussion is given of the general situations in which OCD calculations seem to be adequate. This consists mainly of the case in which an infinite plane source of radiation surrounds a simple building with no interior walls or floors. Then, three cases in which present calculations appear to be inadequate will be discussed in detail. The first case in which calculations appear to be inadequate involves a finite source strip whose width is a few story heights (~50 feet). The two main problems are that the theory assumes that radiation emerging from the inner surface of the exterior walls is symmetric with respect to the horizontal plane, and that the barrier factor for radiation penetrating up through the floor is equivalent to the barrier factor for a plane isotropic source. Possible modification of these two assumptions is discussed. (auth)

**19921** (ORNL-4362) CONCEPTUAL DESIGN OF A DUAL-USE UTILITY TUNNEL BLAST SHELTER FOR WHITE PLAINS, NEW YORK. Boegly, W. J. Jr.; Griffith, W. L.; Nelson, K. P. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-36. 67p. Dep. CFSTI.

Use of underground utility tunnels (utilidors) in urban areas offers a unique solution to the problem of utility maintenance and presents a potential facility for dual-use as an interconnected blast shelter. Even without the special features required for blast protection, utility tunnels connecting the basements of large buildings could serve a very useful function by providing radiation-protected passageways between fallout shelters. This potential exists on many college campuses today. A survey was conducted on current utility tunnel practice in the conceptual design of a utilidor system for an urban renewal area. The Central Renewal Project in White Plains, New York, was selected for this study. A complete utility system for the White Plains Central Renewal Project would cost 8.2 million dollars. The cost of the tunnel and associated services would be 4.4 million dollars. A conventionally buried utility tunnel system would cost 4.7 million dollars. Conversion of the tunnel system to a dual-purpose blast shelter for 20,000 people would require an extra expenditure of 5.8 million dollars ($290/person) if a button-up (ventilation isolation) period of eight hours is required. This would be reduced to 5.0 million if the button-up time were reduced to two hours. (auth)

## Radioactive Material Handling

*Refer also to abstracts 19817, 19847, and 19915.*

**19922** (CONF-680610-, pp 166-84) CONTAINMENT IN $PuF_6$. Kessie, R. W. (Argonne National Lab., Ill.).

Studies on the containment of $PuF_6$ include hydrolysis of $PuF_6$ on glass in the presence of moisture, and the burst release of $PuF_6$. A rate equation was obtained for the hydrolysis of $PuF_6$ using a packed bed of 3.2 mm-OD spherical glass balls. Small-scale equipment was designed to study the effects of sudden releases of pure $PuF_6$ into air containing moisture over the range typical of the atmosphere and under conditions similar to those in glove boxes currently used for work on $PuF_6$. The results indicated that the penetration times the square of the weight of $PuF_6$ released ($W_p$) would be expected to correlate the effects if both agglomeration and loading were significant. Studies were also made on basic processes in filtration using numerical relaxation techniques. (P.C.H.)

**19923** (KY-551) DEMONSTRATION FUEL ELEMENT SHIPPING CASK FROM LAMINATED URANIUM METAL. PART II. FABRICATION AND COSTS. Smith, V. A.; Loveland, C. W. (Paducah Gaseous Diffusion Plant, Ky). Mar. 20, 1969. 31p. Dep. CFSTI.

The fabrication of a demonstration fuel element shipping cask utilizing laminated depleted uranium as shielding material is described. A detailed presentation is given of the fabrication, machining, cleaning, and heat treating operations followed in producing the cask. Machining characteristics of uranium are described and special control measures together with equipment requirements are presented. Emphasis is placed on distinctive techniques used with uranium materials, and discussion of fabrication used with other, more common construction materials is minimized. Cost experience is detailed to permit its extrapolation to conventional industrial experience. (auth)

**19924** (WASH-1122) RESEARCH AND DEVELOPMENT FOR SAFEGUARDS. Inman, Guy M. (Office of Safeguards and Materials Management (AEC), Washington, D. C.). Dec. 1, 1968. 285p. Dep. GPO $2.25.

The present status of active research and development programs for safeguards is indicated and summaries of the results of completed contracts are given. Available information concerning unclassified contracts awarded from the beginning of safeguards activities in 1955 until October 1, 1968 is included. The active contracts are being supported by the ACDA, BMwF, IAEA and the USAFC. In addition to serving as a historical review of safeguards research and development, the document also includes the "period of contract" and contract price so that the direction of effort and the increasing expenditures can be clearly seen. Research organizations should be able from the summaries presented to identify areas in which they have special technological competence to contribute to the new and expanding field of peaceful use safeguards. (auth)

**19925** IMPROVEMENTS IN OR RELATING TO TRANSPORT CONTAINERS FOR RADIOACTIVE MATERIALS. Lindsay, Graham Eades; Evans, Leslie Samuel (to United Kingdom Atomic Energy Authority). British Patent 1,145,983. Mar. 19, 1969. Filed May 7, 1965.

The container described is intended particularly, but not exclusively, for the transport of irradiated nuclear fuel elements, and complies with international regulations covering the transportation of radioactive materials. It comprises a vessel of impact resistance construction having removably located therein a number of shielding inserts arranged to provide a space or spaces for holding the radioactive material. The inserts are interchangeable to allow the dimensions of the space or spaces to be varied to accommodate different shapes or sizes of radioactive material without necessarily adjusting the dimensions of the container vessel. It is pointed out that the non-interchangeability of present containers leads to difficulties of transport facilities and handling arrangements, with resultant increases in cost. The inserts may be arranged to form a central space, allowing for the provision of a separate basket to position the radioactive material, or more than one such space may be provided. In one form the container vessel is circular in cross-section, with dished ends. The vessel may include an extension portion adopted for insertion between its body and a removable lid or top portion, to accommodate long length loads. External heat transfer fins may also be provided, and some of the fins may be extended to the base of the vessel to form support members. (UK)

**19926** IMPROVEMENTS IN OR RELATING TO IRRADIATION EQUIPMENT. Grant, John; Shepherd, George Henry (to United Kingdom Atomic Energy Authority). British Patent 1,146,674. Mar. 26, 1969. Filed Aug. 13, 1965.

The equipment described relates particularly to portable self-contained apparatus in which a sample may be moved into and out of a shielded source container. An irradiation chamber which contains the radioactive source has an opening communicating with an adjacent region. A shielding plug is adapted to receive the sample to be irradiated, with counter-balancing means to reduce the weight of the plug; this plug is movable relative to the source by motor drive, and may thus be transferred from the irradiation region to a position where the sample may be retrieved, or vice versa. At least a part of the plug is positioned in the communicating opening at all times during operation of the apparatus, irrespective of the position of the sample with respect to the source. The plug is preferably supported on constant tension spring elements. (UK)

# INSTRUMENTATION

## Radiation Detection Instruments

*Refer to abstract 20081.*

### General Detectors and Monitors

*Refer also to abstracts 20080, 20217, and 20728.*

**19927** (AEEW-M-788) MEASUREMENT OF THE AXIAL VARIATION IN SENSITIVITY OF 1/4-INCH DIAMETER FISSION CHAMBERS. Burholt, G. D. (Atomic Energy Establishment, Winfrith (England)). Oct. 1967. 17p. Dep. CFSTI. UK 4s. 0d.

Measurements were made of the axial variation in sensitivity of two ¼-inch diameter $^{235}U$ fission chambers, and the effective center of each was determined by measuring the response of the chambers as they were scanned by a collimated beam of neutrons. The effective center was determined with an error of ±0.006 inch, whereas the physical center could only be estimated to within ±0.014 inch. The effects of axial non-uniformity of sensitivity were considered for measurements in high neutron flux gradients, and it was shown that small corrections were required in some cases. (UK)

**19928** (ANL-Trans-739) INVESTIGATION OF PULSE SPECTRA FROM A SINGLE PAIR OF IONS IN A PROPORTIONAL COUNTER. Pomanskii, A. A.; Sazhina, I. P. (Akademiya Nauk SSSR, Moscow. Institut Fiziki). Translated by Elmar K. Wilip (Argonne National Lab., Ill.), from Preprint No. 173. 19p. Dep. CFSTI.

Pulse spectra of single primary electrons produced by ultraviolet and x radiation in a proportional counter were determined for a variety of gases. The theory of the development of single-electron avalanches in proportional counters is discussed, and experimental procedures are described. (W.H.K.)

**19929** (CONF-680507–, pp 84-9) SEMICONDUCTOR MEASUREMENT OF FALLOUT. Huber, O.; Winiger, P.; Halter, J. (Fribourg Univ. (Switzerland). Physikalisches Institut). (In German).

Two γ-ray spectra of recent fission products, measured by a well-type NaI crystal and a Ge(Li) diode are compared. The high energy resolution of the small semiconductor compensates nearly its low detection efficiency and allows a much more reliable analysis of complex spectra within the monitoring of radioactivity. An example of an analysis is given. (auth)

**19930** (CONF-680507–, pp 194-201) USE OF LIQUID WHOLE-BODY COUNTER FOR RAPID MEASUREMENT OF LARGE POPULATION GROUPS. Poretti, G.; Zuppinger, A. (Bern Univ. (Switzerland). Radium Institut). (In German).

Because of its 4π geometry a liquid whole body counter (LWBC) shows a very high sensitivity and should prove very useful for a quick measurement of the inner contamination of large groups of people in a very short time. During the National Exhibition at Lausanne (Switzerland) in 1964 it was possible to measure a relatively great number of persons with a LWBC in a short time and with a working-team of only three persons. If large groups of people are to be measured, the question arises whether it is necessary to have a complete radiation spectrum for each person or if one should confine oneself to the determination of typical nuclide groups in order to be able to proceed more rapidly. The relatively poor resolution of liquid scintillators is not necessarily a handicap in the above-mentioned case. The measurements at Lausanne showed that a relatively simple computer-program allows a good separation of two or three nuclide values. The procedure allows for a rapid detection of contaminated individuals in the population, and simultaneously their separation into seriously, moderately or slightly contaminated groups. This possibility should facilitate additional clinical examinations by specific measurements of particular organs or of body liquids. The LWBC of Berne allows, among other things, the measurement of body sectors, thus making possible a rather rough but useful control of certain organs. A few examples of these possibilities will be cited. Owing to its high sensitivity the LWBC is a very interesting machine for clinical purposes as well. The 4π-geometry allows metabolic tests with activities from 0.1 to 1 μCi which meets especially the requirements of the pediatricians. (auth)

**19931** (CONF-680507–, pp 212-24) ACTIVITY MEASUREMENTS USING THE ACCESSORIES FOR THE DL 50 DOSE OUTPUT METER. Hardt, H.-J. (Bundesamt fuer Zivilen Bevoelkerungsschutz, Bad Godesberg (West Germany)). (In German).

The dose output meter DL 50 is a manageable compact device for civilian protection purposes. It fulfills the requirements of the Federal Board for Civil Defense. A small γ counter with energy filter is introduced for its use as a dose output meter. The measurement range is from 0.1 mR/hr to 50 R/hr. For the detection of β radiation a probe can be attached with which higher contamination of persons and material can easily be detected. The counter used in the probe is 10 times more sensitive to γ radiation than that used in the built-in device so that the meter with attachable probe and uncovered β window is usable for normal radiation protection in the laboratory. The special accessory consists of a small lead shield, a window counter, immersion counter, and supplementary devices for sampling, sample transport, and measurement. The range of the device for activity measurements is therefore limited. The total activity of sufficiently homogeneous samples, liquids, or growing samples (grass or leaves) or the surface contamination of special samples can be determined. The sensitivity of the counter was measured with various emitters. The same number of about 10,000 pulses/min was obtained with immersion tubes for concentration of about 10 nCi/cm$^3$ and with window counters for concentrations of about 30 nCi/g or surface activities of 4 nCi/cm$^2$. In non-shielded arrangement, an environmental radiation of about 10 mR/hr causes this reading as zero effect. The upper limit was established as 100,000 pulses/min. Activities of this order of magnitude can easily be established with the small probe or with the dose meter for γ radiation. More important is the lower range which is 10 pulses/min and is below the normal zero effect. Under catastrophic conditions the measurement accuracy of 0.1% is not obtainable and the reading accuracy in the high ranges was no more than ±10%. In this error must be added the normal error of the readout device, which can amount to ±45%. The systematic error of the measurement, which is determined essentially by the various energies of the β radiation is naturally decisive. Measurement values for $^{90}Sr$ are smaller by a factor of 3 than the values for $^{137}Cs$. It is recommended that the measurements be calibrated to natural potassium. (tr-auth)

**19932** (CONF-680507–, pp 253-6) CONTAMINATION CONTROL IN THE VENTILATING AIR BY MEANS OF A PORTABLE AIR SAMPLER. Suter, Fred (Eidgenoessisches Institut fuer Reaktorforschung, Wuerenlingen (Switzerland)). (In German).

In addition to the continuous sampling devices with direct reading of activity and built-in alarm devices, the introduction of simple, easy to operate, portable air samplers is often advantageous in civilian protection. For the various air contamination measurements occurring in the framework of a civil defense organization, there are basically four different types of air samplers available. (1) Large-volume air sampler (grid dependent) is suitable for short time measurements but is noisy. Its output is several hundred l/min. (2) The laboratory air sampler (grid dependent) is suitable for short and long term measurements. It is practically noiseless and is suitable for use in emergency hospitals. Its output is 5 to 20 l/min. (3) The hand air pump (without current) is for measurements in contaminated country. It has an output of 20 to 30 l/min. The injector pump is non-electrical and is operated by means of compressed air. It is for measurements in contaminated country. The output is 50 to 100 l/min. The possibilities for the use of these four types of air samplers were described. (tr-auth)

**19933** (CONF-680507–, pp 639-43) COMPARATIVE MEASUREMENTS OF THE BACKGROUND IN PROTECTED SPACES FOR WHOLE-BODY COUNTERS. Futtermenger, W. (Technische Hochschule, Hanover (West Germany). Arbeitsgruppe fuer Bautechnischen Strahlenschutz). (In German).

Measurements of the background in seven German whole-body counters were made with a scintillation crystal. The study was extended to whole-body counters with at least 2 m$^3$ usable volume and with shielded walls which reduce the external radiation spectrum by a factor of 20 to 70 at least. The principal component of the shields investigated were old steel, old lead, electrolytic copper, lead with barite, and lead with gypsum. The zero-level spectra obtained were compared with each other. Data on the performance of the shielding, the volume, and the price were tabulated. (tr-auth)

**19934** (KFK-865) TABLES OF EXPERIMENTAL ABSOLUTE TOTAL ABSORPTION PROBABILITIES, INTRINSIC EFFICIENCIES AND PEAK-TO-TOTAL RATIOS FOR LITHIUM-DRIFTED GERMANIUM DIODES. Michaelis, W. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Angewandte Kernphysik). Oct. 1968. 10p. Dep.

Experimental values for the absolute total absorption probability,

absolute intrinsic efficiency and peak-to-total ratio of lithium-drifted germanium diodes for gamma rays between 0.1 and 2 MeV are presented for several detector and irradiation geometries. The sensitive volume of the crystals considered ranges from 3.8 to 28 $cm^3$. Increasing attention is given to the application of such devices in gamma-ray spectroscopy. The results may be used as a guide in determining the optimum experimental conditions for a given gamma-ray energy. (auth)

**19935** (NYO-3246-TA-4) RESEARCH ON AVALANCHE TYPE SEMICONDUCTOR RADIATION DETECTORS. Semiannual Report, July-December 1968. Huth, Gerald C.; Locker, Robert J. (General Electric Co., Philadelphia, Pa. Missile and Space Div.). Jan. 1969. Contract AT(30-1)-3246. 61p. Dep. CFSTI.

Gain uniformity in avalanche-type semiconductor detectors was investigated. The development of avalanche detector instrument instrumentation, both battery and line operated, was discussed. The efficiency of avalanche detectors for electron detection in the 5 to 40 keV range was examined. (B.G.D.)

**19936** (NYO-3409-30) PRELIMINARY INVESTIGATIONS OF PURE AND ACTIVATED $PbF_2$. Blume, H.; Van Sciver, Wesley J. (Lehigh Univ., Bethlehem, Pa.). Oct. 10, 1968. 7p. Dep. CFSTI.

Equipment for studying the photoluminescence and gamma-irradiated scintillation properties of pure and activated crystals of lead fluoride at low temperatures is described. Results are given. (W.H.K.)

**19937** (ORNL-TM-2464) DESCRIPTION OF FACILITY RADIATION AND CONTAMINATION ALARM SYSTEM IN THE THORIUM-URANIUM RECYCLE FACILITY, BUILDING 7930. Hall, C. C.; Knowles, D. J. (Oak Ridge National Lab., Tenn.). Jan. 23, 1969. 27p. Dep. CFSTI.

A facility radiation and contamination system was installed in the Thorium-Uranium Recycle Facility, Building 7930, to continuously monitor gamma radiation, neutron radiation (burst and dose), and airborne alpha and beta-gamma contamination. The radiation monitoring instruments and associated system components provide health physics information, sound local alarms when abnormal conditions occur, and indicate the abnormal condition on a central panel. Radiation monitoring instruments actuate the building evacuation system when specific levels of radiation or contamination are reached. (auth)

**19938** (RT/FI-(68)54) IMPROVED METHODS FOR THE MEASUREMENT OF GAMMA EXPOSURE RATE IN THE NATURAL RADIATION ENVIRONMENT. Cardinale, A.; Frittelli, L. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1968. 35p. Dep.

The separate contributions to the exposure rate, due to the natural gamma background radiation, can be measured, directly in field, by means of spectrometric methods. Though these methods are rather crude and unsophisticated, good precision can be obtained in the results, by using proper elaboration systems. A calibration method is discussed for measurements of exposure rate, using a 3 in. × 3 in. NaI(Tl) detector. The system of elaborating field spectra for giving exposure rate is discussed too. Some results obtained are presented in comparison with the data furnished by a very sensitive ionization chamber. (auth)

**19939** GERMANIUM DETECTORS COMPENSATED BY LITHIUM ION MIGRATION. PART 1. CHARACTERISTICS AND ACTUAL PERFORMANCE IN $\gamma$ SPECTROMETRY. Delporte, R. (Univ., Liege). Ind. Chim. Belge, 33: 335-42(1968). (In French).

Resolution, linearity, and efficiency of the Ge(Li) detector are described. The principal sources of noise which limit resolution are noise of electronic origin, fluctuations in the number of electron-hole pairs created, and fluctuations in the yield of collected charge carriers. Noise level contributions are calculated for a high-performance spectrometer using a low-noise preamplifier provided with a FET. The linearity between 0 and 2600 keV has been demonstrated. The variation of efficiency with photon energy is a result of photoelectric and Compton effects and pair production. The efficiency above 200 keV is always superior to that calculated from photoelectric absorption considerations. The efficiency of a 54 $cm^3$ Ge(Li) diode is comparable to that of a 1 × 1½ in. NaI(Tl) crystal. For photons of more than 1.5 MeV energy, experiment deviates badly from theory. (BBB)

**19940** CALCULATION OF $\gamma$ BACKSCATTERING FOR NARROW RADIATION BEAMS. Koch, Siegfried (Technische Univ., Dresden). Wiss. Z. Tech. Univ., Dresden, 15: 1257-60(1966). (In German).

A limited approximation relation for calculation of the backscatter rate of $\gamma$ radiation is derived and discussed. The equation derived is usable for sufficiently small radiation beams where the quanta that strike the detector are scattered in an essentially simple manner. The geometry of the apparatus used to measure the small beam of radiation is shown, indicating how much the axis of the source and detector collimator intersect the scattered components. The development of the equation for evaluation of the backscatter rate is described in detail. The geometric relations of the primary radiation path and the limitation of the scattered volume produced by the pyramid used for approximation of the detector aperture angle are represented schematically. (BBB)

**19941** INSTRUMENTATION ELECTRONIQUE EN PHYSIQUE NUCLEAIRE. (MESURES DE TEMPS ET D'ENERGIE). (Electronic Instrumentation in Nuclear Physics. (Measurement of Time and Energy)). Samueli, J.-J.; Pigneret, J.; Sarazin, A. Collection de Monographies d'Electronique Publiees Sous la Direction de M. Ponte et P. Grivet. Paris, Masson et Cie, Editeurs, 1968. 287p. 70 F.

The discussion of electronic instrumentation in nuclear physics covers scintillation detectors, photomultipliers, energy resolution of scintillation detectors, and semiconductor detectors and nuclear spectroscopy. Pulse analysis is discussed and includes preamplifiers for detectors, linear pulse amplifiers, methods of analysis of gamma spectra and complex gamma spectra obtained from scintillators and germanium detectors, and particle identification. Lastly time measurements are discussed including coincidence techniques, time resolution for scintillation detectors, the use of semiconductor detectors for time measurements, and the electronics associated with time measurements. (J.F.P.)

**19942** GERMANIUM DETECTORS COMPENSATED BY LITHIUM ION MIGRATION. PART 2. APPLICATIONS TO ELEMENTAL CHEMICAL ANALYSIS. Delporte, R. (Univ., Leige). Ind. Chim. Belge, 33: 440-8(1968). (In French).

A survey of recent work illustrating the utility of the high resolution of Ge(Li) detectors for elemental analysis is given; in particular, examples indicating possibilities for improved neutron activation analysis are chosen. The resolution of the $K\alpha_1$, $K\alpha_2$, $K\beta_1$, and $K\beta_2$ of heavier elements and mixtures of them is achieved. Examples include analysis of Hf in Zr, nondestructive analysis of Al, analysis of sulfate mineralization, concentration of lanthanides in rock samples, analysis of Ag in minerals, air pollution studies, biomedical applications, archeological analysis, nondestructive analysis of nuclear fission products, and activation analysis using charged nuclear particles. Each case permits sufficient resolution to allow nondestructive analysis of the sample. (BBB)

**19943** DETERMINATION OF DETECTION EFFICIENCIES OF NaI SCINTILLATION DETECTORS FOR GAMMA-RAY SOURCES DISTRIBUTED IN WATER. Moriuchi, Shigeru; Matsushita, Kozo (Japan Atomic Energy Research Inst., Tokyo). Radioisotopes (Tokyo), 18: 15-21(Jan. 1969). (In Japanese).

Measurements for determining detection efficiencies of three NaI scintillators having dimensions of 1 in. × 1 in. to 2 in. × 2 in. were made for various gamma-ray sources distributed uniformly in water tanks. Gamma-ray energies are ranged between 0.13 MeV and 1.84 MeV, and water tanks are cylindrical ones having the diameter equal to the depth. Results were expressed by approximation formulae as a function of radii of volume-equivalent spherical water tanks, and the responses in infinite water volume were extrapolated. Counting efficiencies for a unit gamma emitter per unit volume can be calculated by this equation with reproducing errors of ±5%. The energy response was fairly flat over a wide energy range with a small tank of about 20 cm in radius, independent of the size of scintillator. Furthermore, photon number buildup factors were derived from the formula and compared with those calculated from energy buildup factors given by Goldstein, et al. The values obtained experimentally were about one half of Goldstein's. This fact implies that it would cause big errors in the determination of counting efficiencies of gamma detectors to use the buildup factors for photon numbers calculated from those for energy or dose. (auth) (NSA of Japan)

**19944** SEMICONDUCTOR GAMMA-RAY DETECTORS. Sakai, Eiji (Japan Atomic Energy Research Inst., Tokyo). Oyo Butsuri, 38: 2-19(Jan. 1969). (In Japanese).

Recent progresses on studies of charge collection process in Ge(Li) detectors and problems in their manufacturing are described. Topics such as radiation damage to Ge(Li) detectors, well-type Ge(Li) detectors, double-diode Compton suppression gamma-ray spectrometers, and CdTe detectors are also reviewed. (auth) (NSA of Japan)

**19945** DETECTION YIELD OF A COUNTING INSTALLATION USING A SCINTILLATING MEDIUM ASSOCIATED WITH AN ELECTRON PHOTOMULTIPLIER. Duquesne, Maurice (Institut du

Radium, Paris). Compt. Rend., Ser. A, B, 267: 1347-9(Dec. 16, 1968). (In French).

From the knowledge of the distribution characterizing the photoelectron spectrum of a detection chain and of the distribution representing the spectrum of pulses coming from the detection of a monoenergetic radiation releasing an energy $E_0$ in the scintillating medium, the value $\bar{n}$ of the mean number of photoelectrons associated with $E_0$ and therefore the detection yield of the installation can be determined. (tr-auth)

**19946** INSTRUMENTATION FOR A NUCLEAR REACTOR. Nomura, Tsutomu (to Nippon Atomic Industry Group Co., Ltd.). Japanese Patent 1968-25075. Oct. 29, 1968. Filed Feb. 2, 1965.

Instrumentation for measuring the sub-critical reactivity and the transfer function of a nuclear reactor is described. A neutron detector is installed in each of the two neutron-density detecting systems. The fluctuating signals of power output of the two systems are wave-filtered by a suitable means, and then multiplied together. Thus, a device for analyzing the reactor noise spectrum is obtained. (NSA of Japan)

**19947** THE MAGNETIC MODIFICATION OF $\beta$ RAYS EMITTED BY RADIOISOTOPES. A CONTRIBUTION ON THE PROBLEM OF IMPROVED RESOLUTION OF ELECTRON MICROSCOPIC AUTORADIOGRAPHS. II. Zessack, U.; Fromme, H. G. (Univ., Muenster, Ger.). Z. Wiss. Mikrosk., 67: 225-31(Dec. 1966). (In German).

The effects of a 40-day exposure of Bacillus subtilis labeled with $^3$H-thymidine to a static magnetic field of 800 to 1000 G are reported. The number of labeled bacteria visible with the electron microscope was not increased after exposure to the magnetic field. The resolution was not improved. The theoretical basis for use of a magnetic field to increase the resolution of autoradiograms is discussed. It is estimated that a constant magnetic field of ~1000 G could place a 10-keV $\beta$ particle into a spiral trajectory of 340 $\mu$m radius. A curve radius of 340 $\mu$m calculated for a path length of 2.5 $\mu$m in the emulsion is too great to expect any improvement in the autoradiographic resolution that can be obtained. The experimental findings agreed with this theoretical expectation. (BBB)

**19948** COMPARATIVE RESOLUTION OF SINGLE GAMMA COUNTING AND COINCIDENCE COUNTING IN FOCUSING COLLIMATOR SCANNING SYSTEMS. Hart, Hiram E. (City Coll. New York). Trans. N. Y. Acad. Sci., 30: 580-99(Feb. 1968).

Focusing collimator coincidence scanning (FCCS) with improved resolution was investigated for its range of applicability and to indicate appropriate collimator design by means of a general theoretical analysis. The radioisotope employed in FCCS should either decay by electron capture or exhibit a forbidden transition. The $\gamma$ rays should be less than 0.500 MeV so that relatively thin septa collimators can be used. Both signal photons should be greater than 0.050 MeV to minimize tissue absorption, and the two energies should be sufficiently comparable so that a coincidence event can be easily distinguished energetically from either photon alone. For general use, not involving an on-site reactor or accelerator, the physical half life should preferably be at least 1 day for ease in preparation and handling. On the other hand, a physical half-life much greater than 1 week may present a radiation dosage problem. Since count rates are reduced when using FCCS, larger doses of radioisotopes are indicated, and to minimize the radiation dose delivered, the decay spectrum should involve as little extraneous ionizing radiation as possible. Internal conversion of signal $\gamma$ rays should be minimal and there should be no alternate pathway, radioactive daughter, or contaminant contributing a photon in the neighborhood of the summed energy. All of the above conditions are satisfied by $^{111}$In, but this may be difficult to produce routinely. If used freshly prepared before positron emission from its $^{48}$V daughter can build up significantly, $^{48}$Cr is also a possibility. A group of isotopes which, though somewhat less suitable, are most likely to be available is tabulated. (BBB)

**19949** GAS SCINTILLATION DETECTORS AND THEIR APPLICATION. Somorjai, Endre. ATOMKI (At. Kut. Intez.) Kozlem., 10: No. 3, 15-27(Dec. 1968). (In Hungarian).

The optimum shape and optical coating of light pipe for gas scintillation dE/dx counters are determined and pulse-height instability was investigated. The pressure independence up to 350 to 400 torr and the energy-nonlinearity of the gas scintillation phenomenon at low energies are pointed out. The influence of an electrostatic field generated inside the scintillation volume is studied. Some features of the gas-scintillation counter-telescope are described. (auth)

**19950** IMPROVEMENTS IN AND RELATING TO ELECTROMAGNETIC RADIATION DETECTORS. (to Honeywell Inc.). British Patent 1,146,526. Mar. 26, 1969. Priority date May 6, 1965, United States.

A Geiger–Mueller-type detector system for detecting electromagnetic radiation and particularly ultraviolet radiation is described. The system is designed so that discharge of a first G-M counter initiates a discharge in a second G-M counter so that the first counter is protected against electrode sputtering. (W.H.K.)

**19951** COUNTING WITH LIQUIDS. White, David R. (Kent and Canterbury Hospital, Canterbury, Eng.). Radiography, 34: 99-105(May 1968).

Characteristics of the liquid scintillation process and the methods, equipment, and physical bases used are discussed and illustrated. Important terms are defined and their functions are outlined. These include scintillator or phosphor, solvents, primary solutes, secondary solutes, fluorescence, phosphorescence, and luminescence. Important features of practical counting that are described include machine settings, type of mix, volume of sample, and chemical and color quenching. Techniques devised for measuring quenching corrections such as internal standardization, the channels ratio method, and external standards are described. Effects of temperature and light exposure are discussed. Precautions to be used in sample preparation are presented. Miscellaneous counting techniques, such as suspension counting and the measurement of filter papers and disks, use of gelling agents, and radioactive filter papers are summarized. There are many variables in the liquid scintillation process and extreme care has to be exercised to attain reliable measurements. (BBB)

**19952** AUTOMATION OF DATA COLLECTION AND ANALYSIS IN LUNG SCANNING WITH RADIOACTIVE GASES. Kingaby, G. P.; Glazier, J. B.; Hughes, J. M. B.; Maloney, J. E.; West, J. B. (Hammersmith Hospital, London). Med. Biol. Eng., 6: 403-8(Aug. 1968).

Blood flow and ventilation per unit lung volume were measured by scanning the lung with scintillation counters after the intravenous injection or inhalation of $^{133}$Xe. A data logger was specially designed for parallel collection of the count rate at any level in the lung and the calculations of blood flow per unit lung volume at each level on punched paper tape in a form acceptable for analysis by a computer. A detailed description of how information was presented to the data logger and examples of the tape output are given. Regional blood flow was calculated. The sequence by which a single scan is committed to tape is described. Results were obtained in tabulated and graphical form within a few minutes. A print-up of the results obtained finally from the computer, where blood flow per unit lung volume is plotted against lung distance is shown in graphical and tabulated form. The results obtained by the automated and nonautomated techniques are compared. (BBB)

**19953** DEVICE FOR RECORDING MULTIPLE SCINTIGRAMS IN SCINTILLATION SCANNING. Furukawa, Yasune Japanese Patent 1968-27681. Nov. 29, 1968. Filed Jan. 18, 1962.

In the scintillation scanner proposed for medical uses a plurality of the scintigram-recording devices are installed. The output pulse signals from scintillation detectors are assorted according to the levels of pulse count-rate and then recorded in the respective recording devices. A plurality of the differing color scintigram-recording devices are installed, and the pulse signals from scintillation detectors are color-assorted and recorded, according to the levels of pulse count-rates, in the respective recording devices. (NSA of Japan)

**19954** EXPERIMENTAL EVALUATION OF TWO-CRYSTAL SCANNING GEOMETRY FOR WHOLE-BODY COUNTING. Chhabra, A. S. (Bhabha Atomic Research Centre, Bombay). Health Phys., 15: 123-32(Aug. 1968).

Experimental data on the response of the two-crystal scanning geometry for whole-body counting was obtained with a $^{137}$Cs point source moving inside a phantom made out of Hardboard sheets which had shape and other parameters approaching that of the human body. Similar data were also obtained for the multicrystal geometry, and it was found that the two-crystal scanning geometry gave far less deviation for different locations of the source inside the phantom. It was also found that, with extra counting time on the head side in the scanning geometry, improvement in response was obtained for the source movement along the middle and from middle to side of the phantom only, whereas for all other patterns of source movement there was no improvement in the response over that obtained with uniform speed. The deviations in the counting efficiency for the scanning geometry were on the low side compared to the computed and experimental values reported by Naversten for a simplified phantom of water and Masonite and of 20 cm thickness. (auth)(UK)

**19955** MULTIPLIER FOR PARTICLE IDENTIFIER (Engineering Materials). (Los Alamos Scientific Lab., N. Mex.). (CAPE-1849).

6 drawings.

A multiplier used with the E-dE/dX particle identifier in the Vela 5 satellite energetic particle experiment is described. The identifier is used to determine mass and charge number of different particles. The multiplier is a gated constant current circuit which performs a 2-pulse multiplication. The multiplication time is proportional to pulse height and varies between 1.5 and 15 μsec. The multiplier output is a reasonably accurate representation of the product of the input pulses. It is nearly independent of temperature. (For details see TID-4100, Suppl. 51; see also NSA 23: 4806). (F.S.)

**19956** DETECTOR MEANS FOR INDICATING A PREDETERMINED INTENSITY OF RADIATION. Smith, Peter H. (to J. Lyons and Co., Ltd.). U. S. Patent 3,423,679. Jan. 21, 1969. Filed Sept. 30, 1963.

This application discloses a radiation detector comprising a gas discharge tube having two electrodes connected to an antenna for coupling rf energy into the gas discharge tube. The gas within the tube is excited by an ac signal transformer coupled to the gas discharge tube. The exciting signal is sufficiently intense to ionize the gas within the tube, and when the intensity of an rf field at the antenna exceeds a predetermined value, this is marked by an increase in the intensity of the glow discharge of the gas tube and a change in the color of the glow. (Offic. Gaz.)

**19957** DETECTOR ARRAY WITH ELECTRODE CONNECTIONS. Autrey, Evert A. (to Santa Barbara Research Center). U. S. Patent 3,426,198. Feb. 4, 1969. Filed Apr. 29, 1966.

A detector array comprising individual substrate modules having opposed parallel surfaces generally perpendicular to a third surface is described. The third surface is provided with a plurality of detector material segments. The other surfaces have electrode leads plated thereon electrically connected to each segment of detector material. In an array pattern, the modules may be offset as seen in plain view to provide convenient electrical lead connection. (Offic. Gaz.)

**19958** GEIGER-MUELLER TUBE WITH WINDOW AND INTERNAL HELIX. Mackintosh, Ian William (to North American Philips Co., Inc.). U. S. Patent 3,430,086. Feb. 25, 1969. Priority date Feb. 28, 1964, Great Britain.

A Geiger–Mueller tube having a cylindrical metal envelope provided with a thinner wall portion serving as a window to enhance the detection of low-energy radiation is described. The tube contains on its interior a wire helix of a high atomic number to increase the electron emission efficiency to high-energy radiation to enhance the response thereto. (Offic. Gaz.)

**19959** SENSITIVE, QUICK RESPONSE IONIZATION CHAMBER. Taylor, Randolph G. (to Secretary of the Navy). U. S. Patent 3,430,087. Feb. 25, 1969. Filed Nov. 4, 1966.

An ionization chamber having a cylindrical anode with an axially disposed wire electrode operable for detection of ionizing radiation in a range of from about 0.5 to about 8.0 angstrom units with a fast recovery is described. Fast response is brought about by modification of the cathode to include vane-like screen structures secured thereto by brazing, welding, or any other suitable manner. The vane-like structures extend radially out from the cathode with their outer edges spaced from the anode. The tube is provided with a gas filling of krypton or argon with a beryllium window through which the ionizing radiation enters the chamber. (Offic. Gaz.)

**19960** FILM ISODOSE PLOTTER. Kurihara, Shigeyasu; Sano, Terusato (Tokyo Shibaura Electric Co., Kawasaki, Japan). Toshiba Rebyu., 24: 158-63(Feb. 1969).

One of the most important matters in planning radiation therapeutic treatment is to know the dose distribution in the patient's body. The film isodose plotter, utilizing film densitometry, gives accurate isodose curves. A film is set in sliced phantoms and radiation beams are irradiated under the conditions, such as rotational, pendulum, skip, multiport, and wedge techniques, identical with those in actual therapeutic treatment. This apparatus is composed of an optical unit that detects the film density, a recorder that plots the positions of the preset percent doses, and a scanning unit that simultaneously scans the optical unit and the recorder. The optical unit consists of a light source (a tungsten lamp) and a light detector (a photomultiplier tube). The output signal of the photomultiplier is amplified logarithmically and then analyzed by ten discriminators. The recorder makes from the discriminator output ten isodose curves in five colors. (auth)(NSA of Japan)

**19961** RADIATION DETECTOR FOR WIDE-TEMPERATURE-RANGE OPERATION. Molitor, Robert L. (to Nuclear-Chicago Corp.). U. S. Patent 3,426,232. Feb. 4, 1969. Filed Mar. 19, 1965.

A flow-type proportional counter for use in gas chromatography employs a tetrafluoroethylene insulator for support of the anode wire. The insulator is bevelled and seated in a correspondingly bevelled end of the tubular cathode. A spring maintains the gas seal despite the elevated temperatures encountered in each period of use. (Offic. Gaz.)

**19962** DETERMINATION OF RAINFALL RADIOACTIVITY. Goupil, Jean (to Commissariat a l'Energie Atomique). U. S. Patent 3,423,587. Jan. 21, 1969. Priority date Sept. 1, 1964, France.

Apparatus described for determining the radioactivity of rainfall includes a collector for the rainfall having an outlet pipe connected to a beta-ray detecting cup. An outflow regulating device is disposed on the downstream side of the cup and is controlled by a pressure pick-up which responds to the level of the water in the collector so that the flow regulating element controls the flow at a value proportional to the level of the water. Measuring means are connected to the beta-ray detecting cup and volume measuring means measure the volume of water passing through the regulating device. (Offic. Gaz.)

**19963** NUCLEAR REACTORS. Downs, Terry; Hyun, Kyung Ho (to English Electric Co., Ltd.). British Patent 1,146,554. Mar. 26, 1969. Filed Jan. 20, 1967.

Reference is made to radiation detection systems, for nuclear reactors, of the pulse ionization chamber type. If a single coaxial cable is employed, for example where the collector and positive polarizing electrodes (which may be combined together) are connected through the core of a coaxial cable with the positive pole of a high voltage dc source, the negative polarizing electrode being connected to the negative pole through the cable sheath, pulse breakdowns in the cable will produce noise pulses which become superimposed on the signal pulses from the collector electrode; and it is not always possible, under the high temperature conditions prevailing in a nuclear reactor, to guarantee that pulse breakdown will not occur. In the system described the negative polarizing and collector electrodes are connected respectively to the negative pole of the voltage source and to the measuring instrument through the cores of two separate coaxial cables, the positive polarizing electrode being connected through coaxial conductive elements of both cables to the positive pole of the source. The source includes filter means for removal of any noise pulses due to pulse breakdown in the cable connected to the negative polarizing electrode. Pulse breakdown has thus a negligible effect on the signal pulse. Where in the case of an ionization chamber having coaxial cylindrical electrodes the polarizing electrodes are outside the collector electrode, the increased area available for ion collection increases the space charge limit for a given voltage, and it is possible to obtain a higher pulse breakdown voltage in the cable with the core negatively polarized with respect to the sheath. The system may include a monitoring unit connected through the core of a third coaxial cable with the negative polarizing electrode, the third cable having a coaxial conductive element connected with the conductive elements of the other two cables. Triaxial cables may also be employed, with an earthed outer sheath. (UK)

**19964** SCINTILLATION COMPONENT FOR USE IN RADIATION DETECTION DEVICES WHICH ARE SUBJECT TO WIDE TEMPERATURE VARIATIONS. Menefee, Julious M.; Erker, Joseph W. (to Kewanee Oil Co.). U. S. Patent 3,426,195. Feb. 4, 1969. Filed Mar. 10, 1966.

The packaging of a scintillation crystal or crystals for use in radiation detection which is more rugged and resists physical or optical damage over wide temperature ranges is described. It comprises a light-tight metal container having its inner surface coated with a reflective material. An opening is provided in the container consisting of a transparent window hermetically sealed to the container. The scintillation crystals in the container are surrounded by a normally liquid coupling material which in turn is surrounded by a core which is made up of hydrogeneous materials such as Lucite, polyvinyl toluene and polystyrene. The core material is solid at normal operating conditions for the detector in which the scintillation component is used but which softens and becomes plastic at higher temperature so as to accommodate the expansion of the scintillation crystal. (Offic. Gaz.)

**19965** NUCLEAR FLUX MEASURING APPARATUS EMPLOYING CURRENT FLUCUTATIONS FROM NEUTRON DETECTORS. Fowler, Eliot Patrick; Harrison, Donald; Levell,

Roy William (to United Kingdom Atomic Energy Authority). U. S. Patent 3,426,199. Feb. 4, 1969. Priority date July 22, 1964, Great Britain.

Neutron flux is commonly measured with an instrument responsive to the mean current from an ion chamber at high flux levels and with a pulse counting equipment at the lower flux levels. An alternative approach with which the instant invention is concerned uses the statistical fluctuations of the current from an ion chamber as a measure of neutron flux. This varying current is filtered to provide an ac input signal which is fed to a log ac amplifier and a rectifier providing a dc output proportional to the rate of pulse generation in the chamber. (Offic. Gaz.)

**19966** CALIBRATION OF A $4\pi\gamma$ IONIZATION CHAMBER. Oncescu, M.; Rebigan, Fl. (Inst. of Atomic Physics, Bucharest) Rev. Roum. Phys., 13: 837-45(1968).

A method of calculating the response to gamma radiation of a well-type ionization chamber is described. The instrument response is expressed as current per millicurie for each radionuclide whose gamma energies lie within the 0.1 to 4 MeV range. A practical adaptation of calibration curve was made so that it has an accuracy of ±5%. Measurements were made using $^{226}Ra$, $^{198}Au$, $^{137}Cs$, and $^{54}Mn$ primary standards and they show agreement within the experimental errors. (auth)

**19967** DETECTION OF LOW ENERGY RADIATION BY REAL-TIME CORRELATION OF NOISE-DERIVED PROBABILITY FUNCTIONS. Schnurr, L. E. (Mid-Essex Technical Coll., Chelmsford, Eng.). Nucl. Energy, 12-14(Jan.-Feb. 1969).

The principle of extracting random noise data from noise at low signal-to-noise ratio is explained. It is based upon sampling the change of probability density of noise at a number of given levels when a signal of arbitrarily small value is present, and correlating changes in each sample value so that a unique condition representing the presence of a signal may be obtained. The principle is modified for practical use and a constricted system is explained in block diagram form. Wave forms with signal-to-noise ratios of 0.1 and 0.04 are presented. (UK)

**19968** HIGH RESOLUTION SCANNING DEVICE FOR DETERMINING THE DISTRIBUTION OF WEAK BETA ACTIVITY IN A PLANAR SURFACE. Wray, F. J.; Tinker, P. B. (Oxford Univ.). J. Phys., E (London), 2: 343-6(Mar. 1969).

A scanning device is described which allows accurate localization in one dimension of the distribution of weak beta radiation ($^{14}C$ and $^{35}S$) over a planar surface. A single uncooled photomultiplier tube is used with a very small anthracene crystal to achieve both high detection sensitivity and a low background counting rate. Methods of cutting small anthracene crystals and of making rectangular slit collimators of 0.1 mm width are described. A geared drive from a constant speed motor moves the combined photomultiplier, crystal and collimator system over the labelled surface, and the distribution of activity is recorded automatically on a chart recorder. For a collimator 0.2 mm wide and 0.7 mm deep moving 0.7 mm above a straight planar edge the instrument's resolution is 0.54 mm, while the comparable value derived geometrically is 0.4 mm. (auth)

**19969** ANALYSIS OF THE DISPLACEMENT OF RADIATION SOURCES, USING BETA-SENSITIVE SEMICONDUCTOR DETECTORS. Lyttkens, L.; Sjoestrand, U. (Univ. of Uppsala). Acta Soc. Med. Upsal., 73: 179-86(1968).

A method by which the displacement of $\beta$-emitting radiation sources is detected with the aid of $\beta$-sensitive semiconductor detectors is described. The method described involved practical testing of a suitable channel setting and eliminating of energies below 50 keV and above an appropriate level, depending on the actual radioactive nuclide used. The radioisotopes used were $^{32}P$, $^{36}Cl$, and $^{137}Cs$. Of the isotopes selected $^{32}P$ was a pure $\beta$ radiator, while the other two also emitted $\gamma$ radiation. Because of the relative insensitivity of the detector used to x-ray and $\gamma$ radiation, the measurements were not affected by this. Analysis of a series of dilutions of $^{32}P$ with a wide energy channel showed that in the analytical equipment there were linear relations between the input and output pulses. There were no coincidence losses up to counting rates equivalent to 400,000 cpm. Good agreement was obtained between the theoretically expected and the empirically measured conditions. The resolving power of the method increased in principle with lower maximal $\beta$ energies ($E_{max}$) and it was possible to detect displacements of the order of 0.1 $\mu$. (BBB)

**19970** RADIATION CAMERA. Harvey, Peter James (to Ekco Electronics Ltd.). British Patent 1,147,384. Apr. 2, 1969. Filed Jan. 6, 1967.

The gamma or positron camera system described is based on an image intensification principle, whereby statistical fluctuations of signal intensity do not materially affect either positional resolution or linearity. The system comprises means for converting emitted radiation into optical signal pulses, means for recording the optical signal pulses as correspondingly spatially distributed electric charges in a charge storage device, a read-out circuit for reading the spatial distribution of the charges, sensing means for producing a sensing signal characteristic of each optical signal pulse, and an optical gate responsive to the sensing signal, whereby only those optical signal pulses having a predetermined characteristic are recorded as electric charges. The sensing means is preferably characteristic of the amplitude of each optical signal pulse and thus indicative of the energy of the radiation. The storage device may comprise a target having an insulating coating upon which the optical signal pulses are stored as spatially distributed positive charges, the read-out circuit comprising means for scanning the target with an electron beam having near zero velocity towards the target, a fraction of the electron beam incident on a point of the target passing through the target to a collector held at a positive relative potential, and at least a proportion of the remainder of the beam being reflected from the target as a function of the charge density to form an output signal. The storage device may comprise a photocathode, and the sensing means may comprise an optical intensifier having a photocathode and an output phosphor, the gate being disposed between the intensifier and the storage device. The converting means may comprise a detector having a matrix of crystal scintillator elements, each such element being optically connected to the intensifier via an optic fiber. Some variants of the system are described, and modes of operation are indicated. (UK)

**19971** REGULATED HIGH VOLTAGE SUPPLY FOR PORTABLE RADIATION DETECTORS. Widman, J. C. (Veterans Administration Hospital, Allen Park, Mich.). Med. Biol. Eng., 6: 555 (Sept. 1968).

A small high voltage supply originally constructed for a portable spark radiation imaging camera (Spintharicon) is also useful as a highly stable supply for Geiger counters operated at high count rates or portable scintillation detectors. The circuit uses an inverter circuit driving a voltage quadrupler. A portion of the output voltage is sensed by the field effect transistor (FET), compared to a reference voltage, and the difference amplified to correct the input voltage to the inverter. Normal fluctuations in temperature and input voltage cause a change in output of less than 1 V. The temperature coefficient of the unit constructed is 0.006%/°C and can be adjusted by altering the FET current or the reference diode current. The output is adjustable in 4 ranges from 1000 to 2100 V. The use of a small 10-turn potentiometer permits voltage adjustment to within 1 V. The regulation is about 0.5% from no load to a full load of 100 $\mu$A. The no load drain and the full load efficiency, which depend on the output voltage, are 100 mW and 40%, respectively, at 1600 V. (BBB)

**19972** DIRECTIONAL AND RANGING SYSTEM EMPLOYING RADIATION DETECTORS. Wilcox, George E. (to Secretary of the Navy). U. S. Patent 3,436,539. Apr. 1, 1969. Filed Dec. 27, 1965.

Apparatus for ascertaining the bearing and range of a known, remotely located radiation source is described. Three scintillation crystal type radiation detectors are arranged in a triangular configuration and have shielding interposed there between which is appropriately shaped for controlling the bearing responsive output signals of three associated photomultiplier tubes which are connected to a multichannel signal processor which, in turn, is connected both to a three-wire magnetic compass indicator for indicating the bearing of the radiation source and to a voltmeter for indicating the range of the radiation source. (Offic. Gaz.)

**19973** THE WHOLE-BODY COUNTER OF THE RCN AT PETTEN. Ackers, J. C. Atoomenergie Haar Toepass., 10e: 285-90(Dec. 1968). (In Dutch).

The whole body counter, used to locate internal radioactive contamination in radiological workers, is described. For this measurement the instrument uses the gamma radiation originating from radioactive materials present in the body. (tr-auth)

**19974** ELECTRONIC SYSTEM FOR PULSE SHAPE DISCRIMINATION IN CsI(Tl). Koehler, M.; Hofmann, A. (Univ., Erlangen, Ger.). Nucl. Instrum. Methods, 68: 268-72(Feb. 15, 1969). (In German).

An electronic system for pulse shape discrimination based on the method of Varga is described. Using CsI(Tl) scintillators this system allows to separate $\alpha$-particles from other reaction products for energies $E \geq 2$ MeV. Protons and deuterons can be distinguished for $E \geq 3.5$ MeV. This arrangement was used in measurements with 14 MeV neutrons. (auth)

**19975** PROCESS OF CHARGE COLLECTION IN SILICON DRIFTED DETECTORS WITH INHOMOGENEOUS DISTRIBUTION OF THE ELECTRIC FIELD. Moroz, Z.; Moszynski, M. (Inst. of Nuclear Research, Swierk, Poland). Nucl. Instrum. Methods, 68: 261-7(Feb. 15, 1969).

An analysis of the charge collection process in a silicon drifted detector is presented, under the assumption that the distribution of the electric field in the detector is represented by a second order polynomial. The shape of the pulses induced by a point charge and a linearly distributed charge is discussed in terms of the place of their generation. Agreement is found between experimentally determined time spreads of pulses generated by monoenergetic electrons, with those calculated using the present analysis of the charge collection process, in contrast to the theory of charge collection in a detector with uniform electric field. (auth)

**19976** OPTIMUM VALUE FOR THE DURATION OF A RATEMETER WEIGHTING FUNCTION. Vincent, C. H. (United Kingdom Atomic Energy Authority, Aldermaston, Eng.). Nucl. Instrum. Methods, 68: 256-60(Feb. 15, 1969).

A method is found for optimizing the duration of the ratemeter weighting function when a variable pulse rate of randomly timed pulses is to be measured. This method is applied to rectangular and exponential weighting functions, as important examples. The method is extended to cover the case where the contribution of each input pulse to the reading is to be proportional to its amplitude, instead of uniform, the distribution of pulse amplitudes being specified. A brief account of methods for obtaining an approximately rectangular weighting function, in principle, is given in the appendix. (auth)

**19977** REPRODUCIBLE MEASUREMENTS OF $^{55}$Fe IN INACTIVE IRON AS A TRACER WITH LIQUID SCINTILLATION COUNTER. Hoyer, F. (CERN, Geneva). Nucl. Instrum. Methods, 68: 351-2(Feb. 15, 1969). (In German).

Count rates of $^{55}$Fe and $^{59}$Fe samples measured by means of a liquid scintillation counter decrease faster than they should do for the half-lives given. The effects found are described and a method for obtaining reproducible measurements is proposed. (auth)

**19978** IMPORTANT POTENTIAL SOURCE OF ERROR IN THE ROUTINE DETERMINATION OF RADIOISOTOPES OF LOW ENERGY BY LIQUID SCINTILLATION COUNTING. Jordan, P.; Koeberle, P. (Technische Hochschule, Zurich). Nucl. Instrum. Methods, 68: 355-6(Feb. 15, 1969).

A possible source of error which may arise in the determination of quenching by the channel-ratio method with an external standard in liquid scintillation counters, when the amplifiers or discriminators are overloaded at high sensitivity levels, is discussed. (B.G.D.)

**19979** LOWER LIMIT OF DETECTION FOR VERY SHORT-LIVED RADIOISOTOPES USED IN ACTIVATION ANALYSIS. Sterlinski, S. (Inst. of Nuclear Research, Warsaw). Nucl. Instrum. Methods, 68: 341-3(Feb. 15, 1969).

The lower limit of detection for a very low-level background ($B < 4$) has been studied. A graph is presented which allows to find quickly, for a given background, the critical value of the count difference and the lower limit of detection. (auth)

**19980** DETECTION EFFICIENCY OF A PLASTIC SCINTILLATOR FOR 20- TO 170-MeV NEUTRONS. Young, J. C.; Romero, J. L.; Brady, F. P.; Morales, J. R. (Univ. of California. Davis). Nucl. Instrum. Methods, 68: 333-4(Feb. 15, 1969).

The neutron detection efficiency of a plastic scintillator 30.5 cm long and 12.7 cm in diameter has been measured for neutron energies from 20- to 170-MeV at thresholds of 2-, 4-, and 16-MeV electron energy. (auth)

**19981** A METHOD OF DETERMINING THE ABSOLUTE SCINTILLATION EFFICIENCY OF AN NaI(Tl) CRYSTAL FOR GAMMA RAYS. West, J. B.; Collinson, A. J. L. (Borough Polytechnic, London). Nucl. Instrum. Methods, 68: 222-8(Feb. 15, 1969).

A method is described to calculate exactly the number of photons emitted per scintillation in an NaI(Tl) crystal when a $\gamma$-ray is completely absorbed. A special crystal geometry is employed, and corrections made for reflection and absorption losses between the crystal and the photomultiplier used as a detector. Spectral measurements are also made, to account for the variation of the photomultiplier response with the wavelength of the light incident on it. An estimate is made of the transmission loss between crystal and photomultiplier in a conventional assembly. (auth)

**19982** LITHIUM GLASS DETECTOR BANK FOR NEUTRON TIME-OF-FLIGHT MEASUREMENTS. Jung, H. H.; Priesmeyer, H. G. (Univ., Kiel). Nucl. Instrum. Methods, 68: 353-4(Feb. 15, 1969).

A lithium glass detector bank for the fast chopper facility at the Geesthacht research reactor (FRG-1) is described. (auth)

**19983** INVESTIGATION OF THE FLATNESS OF RESPONSE OF A MULTI $BF_3$-COUNTER NEUTRON DETECTION SYSTEM. Barrett, R. F.; Birkelund, J. R.; Thies, H. H. (Univ. of Western Australia, Nedlands). Nucl. Instrum. Methods, 68: 277-83 (Feb. 15, 1969).

Reported is a critical investigation of the flatness of response of a neutron detection system consisting of a large moderator with central target of source cavity, beam entrance and exit ports and an array of $BF_3$-counters oriented radially with respect to the cavity. One can construct a system whose neutron detection efficiency deviates little from its theoretically constant value for neutrons in the energy range 30 keV to 5 MeV. This deviation is estimated to be of the order of 1%. (auth)

**19984** NaI(Tl) ESCAPE-PEAK TO PHOTOPEAK RATIOS. Dell, J. R.; Ebert, P. J. (Univ. of California, Livermore). Nucl. Instrum. Methods, 68: 335-6(Feb. 15, 1969).

Escape-peak to photopeak ratios in NaI(Tl) have been measured using clean low-energy sources. For the case of good geometry, and using recent cross sections and fluorescence yields, Axel's expression gives values lower than observed. Monte Carlo results agree closely with experiment. (auth)

**19985** RADIOISOTOPE DIAGNOSIS AND RESEARCH DURING PREGNANCY AND IN INFANTS USING HIGHLY SENSITIVE $4\pi$-WHOLE-BODY RADIOACTIVITY DETECTORS. Heinrich, H. C. (Univ., Hamburg). Monatsschr. Kinderheilk., 115: 457-63(Sept. 1967). (In German).

The construction of the Hamburg $4\pi$ whole-body counter and the determination of the measurement sensitivity are described. The test activities necessary for the measurement of the body retention, such as retention of resorbed $^{60}$Co-vitamin $B_{12}$, are determined. Also, use of the whole-body counter for various function tests is described. (J.S.R.)

**19986** PARTICLE DETECTORS OF USE FOR DETECTING POSITIVE IONS. Brisse, Jean; Renaud, Claude (to Commissariat a l'Energie Atomique). British Patent 1,147,174. Apr. 2, 1969. Priority date Oct. 29, 1965, France.

The design of a system for detecting positive ions, neutral particles, and photons is presented. The positive ions in the beam are electrostatically focused on secondary emission target and the electrons emitted are accelerated through a potential to the scintillation detector. The gain of the detector is independent of the ion energy. (W.H.K.)

## *Nuclear Spectroscopic Instrumentation*

*Refer also to abstracts 21261 and 21331.*

**19987** (NYO-3409-31) PRELIMINARY INVESTIGATIONS OF PURE AND ACTIVATED $CdF_2$ AND OF $PbWO_4$. Blume, H.; Van Sciver, Wesley J. (Lehigh Univ., Bethlehem, Pa.). Jan. 7, 1969. 13p. Dep. CFSTI.

At LHeT (liquid helium temperature) pure $CdF_2$ exhibits two emission bands upon UV excitation: a high energy emission centered at about 380nm, which can be excited mainly below 190 nm, and a low energy emission emitted above 460 nm, which can be excited with much smaller efficiency between 220 and 300 nm. The high energy emission decays with a time constant of 135 nsec and the low energy emission with $3 \pm 1$ $\mu$sec. Upon $^{60}$Co $\gamma$ irradiation pure $CdF_2$ yields scintillation pulses suitable for particle detection at LHe and LNT. The scintillation pulse decays at LHeT with a fast decay component of 135 nsec decay time, belonging probably to the high energy emission, and a much weaker slow component of several $\mu$sec decay time, belonging very likely to the low energy emission. The light sum of the integrated fast part of the scintillation pulse is at LHeT about $1/_1$ of that of a conventional NaI(Tl) scintillator at RT. (auth)

**19988** OPTIMAL CONDITIONS OF CONTINUOUS GAMMA-RAY SPECTRUM REGISTRATION WITH A SINGLE-CHANNEL SPECTROMETER. Jelinek, Vit (Inst. of Applied Geophysics. Brno). Jad. Energ., 15: 100-5(Mar. 1969). (In Czech).

A brief account of the theory of that part of the single-channel gamma-ray spectrometer, which is processing amplified electrical pulses coming from the radiation detector and recording continuously their amplitude spectrum is presented. Special attention is

paid to the problem of noise the record is affected with, and to the question of resolving power. Simple equations have been derived indicating the way of choosing the time constant of the filter, the width of the measuring channel and the registration speed to achieve the required quality of the record at the shortest time possible. Some examples of gamma-ray spectra are added, which illustrate the correctness and practicability of the results derived. This theory can be applied to corpuscular radiation spectrometry, too. Besides, it can be also of interest for some other measurements connected with problems analogical in a certain sense, e.g., for the measuring of gamma-ray activity of rocks with a measuring tool moving in the borehole (so called gamma-logging), or for scanning x-ray and electron diffractograms with a moving detector. (auth)

**19989** METHOD AND APPARATUS FOR COUNTING STANDARDIZATION IN SCINTILLATION SPECTROMETRY. (to Beckman Instruments Inc.). British Patent 1,145,713. Mar. 19, 1969. Priority date Aug. 16, 1965, United States.

A method for quench calibration for scintillation spectrometers is described which uses a two-channel pulse analyzer and a standard sample. The standard and test sample are counted together in both channels and the pulse count from the test sample is subtracted to obtain the net standard count rate in each channel due to the standard alone. The ratio of the net standard count rates in the two channels indicates the degree of quenching. (W.H.K.)

**19990** EQUATIONS OF ELECTRON TRAJECTORIES UNDER THE INFLUENCE OF ORTHOGONAL ELECTRIC AND MAGNETIC FIELDS IN A SEMI-CIRCULAR SPECTROMETER. Antony, M. (Strasbourg Univ.). Indian J. Phys., 42: 309-15(May 1968).

Equations of electron trajectories under the influence of orthogonal electric and magnetic fields in a semi-circular spectrometer are derived. The influence of preacceleration on the resolving power and the transmission of the spectrometer are discussed. (auth)

**19991** GAMMA SPECTROSCOPY WITH SEMICONDUCTORS. Naturwiss. Rundsch., 21: 71-2(Feb. 1968). (In German).

The characteristics of the semiconductor spectrometer are described. This spectrometer is based on the fact that ionization in the crystal produces an electric pulse whose strength is proportional to the energy of the radiation. The electron yield is considerably greater than in a gas ionization chamber. In principle, it is similar to a photoelectric meter. Semiconductors such as Si and Ge can be used. In Ge a 300-keV photoelectron produces $10^5$ ion pairs, which is several times those produced in other devices. Because of this it is possible to measure $\gamma$ energies of 1 keV accurately, while the breadth of the spectral peak from a proton multiplier is ~25 keV. There is some problem in producing physically pure Ge with a perfect crystal structure so that interference voltages will be excluded. The largest component part is the container for liquid $N_2$ used for cooling. The semiconductor spectrometer is readily used with a digital computer. (BBB)

**19992** SOME EXPERIMENTAL SAMPLING RESULTS FOR REGRESSION ANALYSIS APPLIED TO GAMMA RAY SPECTROMETER DATA. II. Pasternack, Bernard S.; Liuzzi, Anthony (New York Univ., N. Y.). Biometrics, 24: 353-62(June 1968).

Empirical sampling results are presented to complement those presented in a previous paper by the authors in which the results presented were based on the first 50 channels of pulse-height data only, to minimize the effect of baseline and gain inconsistencies (essentially changes in the instrument location and scale parameters) which occurred during the sequential counting of the prepared radioactive mixture. Such inconsistencies were apparent when the data were analyzed using 120 channels. Here, use is made of a baseline and gain correction procedure recently developed in the analysis of the same experimentally obtained set of $\gamma$-ray spectrometer data. This correction or transformation procedure represents, in effect, a nonlinear modification of the usual weighted least squares regression technique. Application of this transformation-compensation procedure to the 120 experimentally obtained pulse-height distributions (over 120 channels) resulted in effectively removing the previously encountered instrumental instabilities without significantly disturbing the statistical properties of the regression model under consideration. (BBB)

**19993** NEUTRON SPECTROMETER FOR HIGH NEUTRON FLUX. Kevey, A. (to United States Atomic Energy Commission). U. S. Patent 3,435,219. Mar. 25, 1969.

A neutron spectrometer which has a crystal sample, a detector, co-axial independently rotatable turntables for the crystal sample and the detector, and precision encoders independently and directly connected to each turntable for determining the angles between an incident neutron beam and the crystal sample on one hand and the detector on the other hand is described. A process is contemplated in which a computer is used to rotate the sample in response to variations in the refracted neutrons detected for determining the interatomic characteristics of the sample. (AEC)

**19994** EXPERIENCES WITH THE Ge(Li) DETECTOR FOR HIGH-RESOLUTION GAMMA RAY SPECTROMETRY AND A PRACTICAL APPROACH TO THE PULSE PILEUP PROBLEM. Anders, O. U. (Dow Chemical Co., Midland, Mich.). Nucl. Instrum. Methods, 68: 205-8(Feb. 15, 1969).

Ageing of a Ge(Li) detector results in a decrease of the signal from the detector at a rate of 1% per year. Pulse pileup at high counting rates distorts all peaks in a typical spectrum in the same way depending on the counting rate and the overall shape of the spectrum. Pulser timing corrects for both analyzer dead time and pulse pileup distortion and thus gives the correct timing of the counting interval if peak areas are to be used for quantitative work. Leaky discriminators are proposed for multichannel analyzers to permit effective usage of two-pulser spectrum stabilization. (auth)

**19995** EFFICIENCY OF THE NOVEL HIGH-DUTY-CYCLE TIME-OF-FLIGHT METHODS OF NEUTRON SPECTROMETRY. Quittner, G. (Physics Inst., Seibersdorf, Austria). Nucl. Instrum. Methods, 68: 290-2(Feb. 15, 1969).

The recently proposed modifications of the conventional time-of-flight techniques, the cross-correlation and the Fourier synthesis method, have unusual statistical features which determine the areas of research where they are more promising than the conventional method. The advantage factor of either of the novel methods over the classical one is given simply by half the sum of a spectrum shape factor $H_1$, and the integral background-to-signal ratio $\omega$. Conditions under which the novel methods give better statistical results than the classical method are discussed. (auth)

**19996** LITHIUM DRIFTED GERMANIUM NON-DISPERSIVE X-RAY SPECTROMETER. CERN Cour., 3: 92(Mar. 1969).

Recent advances in the development of germanium x-ray spectrometers are summarized and technical data listed. The use of these devices in the field of research, medicine, industry, and nondestructive analysis is discussed, and the higher efficiency relative to silicon is emphasized. (auth)

**19997** SUMMING Ge(Li)-COMPTON SPECTROMETER WITH HIGH PEAK-TO-TAIL RATIO. Hick, H.; Pepelnik, R. (Inst. of Physics, Seibersdorf, Austria). Nucl. Instrum. Methods, 68: 240-4(Feb. 15, 1969).

The operation and performance of a summing Ge(Li)-Ge(Li)-Compton spectrometer are described. The geometry and the electronic adjustment have been optimized with respect to best response function. Peak-to-tail ratios of 400 for 662 keV and 360 for 1120 keV energy have been obtained. The construction of a summing Si(Li)-Ge(Li)-Compton spectrometer is suggested to avoid small residual contributions of the pair production to the response function. (auth)

**19998** A HIGH PRECISION 180° MAGNETIC SPECTROGRAPH FOR NUCLEAR ENERGY DETERMINATIONS. Alba, F.; Dacal, A.; del Castillo, H.; Roos, R.; Tejera, A.; Mazari, M. (Univ. Nacional Autonoma de Mexico, Mexico City). pp 569-82 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

A high precision 180° magnetic spectrograph was designed for measuring charged particle energies. Absolute energies of alpha particles from $^{241}Am$ and $^{210}Po$ were measured with the spectrograph. (J.W.R.)

**19999** POTENTIAL OF THE Ge(Li) GAMMA-RAY SPECTROMETER FOR PRECISE GAMMA-RAY ENERGY MEASUREMENTS. Heath, Russell L. (Idaho Nuclear Corp., Idaho Falls). pp 251-77 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

A brief description is presented of the development of the lithium-ion drifted germanium gamma-ray spectrometer and its potential for the precision measurement of gamma-ray energies is described. (auth)

### High Energy Physics Instrumentation

*Refer also to abstract 21063.*

**20000** (RHEL/R-169) MAGNETIC SPECTROMETERS FOR HIGH RIGIDITY PARTICLES IN NUCLEAR STRUCTURE PHYSICS. Reeve, P. A. (Rutherford High Energy Lab., Chilton (England)). Sept. 1968. 127p. Dep. UK 15s.

A comprehensive review is given of the design, performance and instrumentation of magnetic spectrometers used with charged particles having momenta greater than 10 MeV/c. (auth)

**20001** MULTIWIRE SPARK COUNTER. Saro, Stefan; Srkalova, Vera (Komensky Univ., Bratislava). Jad. Energ., 15: 96-9(Mar. 1969). (In Czech).

The construction of a multiwire spark chamber is described. Then the dependence of the efficiency of the counter on the position of the source of alpha particles is determined and the variations of the dead time with number of impulses are introduced. In conclusion the possibility of practice application of the multiwire spark chamber for measurements of low level alpha activities is estimated. (auth)

**20002** OPERATION OF A TRACK SENSITIVE DEUTERIUM TARGET INSIDE A NEON-HYDROGEN BUBBLE CHAMBER. Horlitz, G. (DESY, Hamburg); Wolff, S.; Harigel, G.; Leutz, H.; Schmeissner, F. Nucl. Instrum. Methods, 68: 213-21(Feb. 15, 1969).

A track sensitive deuterium target surrounded by neon-hydrogen mixtures in the 4.4 to 5.0 mole % $H_2$ concentration range was successfully operated in the 85 cm bubble chamber at DESY. The sensitivity limits for bubble formation in these mixtures were determined at 30.5 and 31.5°K. For different expansion pressures the bubble densities in the deuterium and in the mixtures were evaluated. The proportion of hydrogen admixture permissible for simultaneous operation of a deuterium target ranges between about 4.5 and 8 mole %. No phase shift in the pressure-time relation of the target and of the chamber could be observed. The target failed after 18,000 expansions due to Mylar(R) rupture at its cylindrical part where, for future experiments, increased thickness for improved performance can easily be provided. Continuing the experiment with the non-operative target, the limits of sensitivity for bubble formation in the 90/10 mole % Ne/$H_2$ mixture region were established at 28 and 29°K. (auth)

## Radiation Dosimeters

*Refer also to abstract 21609.*

**20003** (CEA-CONF-1132) BACKGROUND AND SENSITIVITY OF RADIOPHOTOLUMINESCENT GLASSES: MEASUREMENT VARIATIONS: NEW METHOD OF STANDARDIZATION. Chapuis, Anne-Marie; Francois, Henri; Pichoret-Chartier, Monique ([Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires]). Sept. 1968. 11p. (In French). (CONF-680920-11). Dep.

From 2nd International Conference on Luminescence Dosimetry, Gatlinburg, Tenn.

In order to make successive irradiations of the same dosimeter or to measure low doses delivered during a period of several months, identical control and geometry conditions must be imposed. A new method of calibration was developed which consists in defining for each series of measurements made with an apparatus the characteristics of this apparatus. The studies were made on cylindrical dosimeters. The results showed that it was not possible to define the characteristics of radiophotoluminescence glasses. The characteristics of the dosimeter-reader ensemble can be determined. Therefore every modification of the apparatus causes difficulties which can be eliminated by the calibration method proposed. The method consists in calculating for each series of measurements the background and the mean sensitivity of a lot of dosimeters with the reader used. In order to estimate the exposure of a dosimeter it is necessary to know the sensitivity and the background; the precision obtained varies with the method chosen to evaluate these parameters and can not be better than that of the reader. (J.S.R.)

**20004** (CEA-CONF-1138) REUSE WITHOUT REGENERATION OF RADIOTHERMOLUMINESCENT LiF. Portal, Guy; Francois, Henri; Blanchard, Philippe ([Commissariat a l'Energie Atomique, Paris (France)]). [1968]. 16p. (In French). (CONF-681013-6). Dep.

From 1st European Congress on Radiation Protection and Exhibition on Equipment Using Low Energy and Short Range Radiation Dosimetry, Menton, France.

A lithium fluoride was prepared which has less developed unstable peaks than commercial material and which can therefore be reused without regeneration. Regeneration is the annealed operation made after the use of a sample in order to restore its initial quantities to it. The term annealed is applied to the first operation made after the preparation of the fluoride in order to give it the characteristics sought. The annealing conditions are described in detail. The LiF prepared was used for the manufacture of Teflon detectors which have been used about sixty times. The detectors have excellent reproducibility even for low irradiations. (J.S.R.)

**20005** (CONF-680507-, pp 225-36) POSSIBILITIES OF A THERMOLUMINESCENT DOSIMETRY SYSTEM. Brooke, C.; Gourlet, R.; Lheureux, M. (Manufacture Belge de Lampes et de Materiel Electronique, Brussels).

A complete and operational thermoluminescent dosimetric system is described. The advantages are small dimensions of the detectors and readers connected with a great sturdiness, extreme simplicity and rapidity of reading, high precision, and very wide region of application from mR to kR; and possibility of repeated readings of the accumulated dose, because of a light transfer mechanism. The characteristics of the light transfer mechanism are given. The contamination measurement of humans by the use of a high sensitivity version is examined. (tr-auth)

**20006** (CONF-680507-, pp 237-42) AN EASILY READABLE PERSONNEL DOSIMETER FOR SMALL MEASUREMENTS. Gruber, U.; Kowalski, E. (Landis und Gyr A. G., Zug (Switzerland)). (In German).

For the personal dosimetry of broad populations there are various methods which differ from each other with respect to the radiation effect used, the readability of the dose, operational readiness, and sensitivity to external influences such as temperature, pressure, and impact. The advantages and disadvantages of the individual methods were discussed and a new type of ionization chamber dosimeter of optimum properties was described. The ionization chamber was wired between two condensers, one of which served as charge supply and the other as measurement value integrator. At the beginning of the readiness period, the supply condenser was charged. The connecting point of both condensers served as reference potential and is connected with the dosimeter case. During irradiation a current flows through the ionization chamber and this current was integrated on the measurement condenser, so that the voltage on the measurement condenser is proportional to the total dose. Without irradiation, the measurement condenser was not charged since the insulation of the ionization chamber is interrupted by a protection ring, which is at the reference potential. The error from the finite time constant of the insulation of the measurement condenser begins at the time of the irradiation. The sources of error and the construction of the dosimeter were discussed. The dosimeter was conceived to fulfill the requirement of military and civilian protection. Its most important advantage is the easy readability because of the direct voltage measurement on the measurement condenser. (tr-auth)

**20007** (CONF-680507-, pp 244-8) THE BUTTON DOSIMETER: A POSSIBILITY FOR SIMULTANEOUS MEASUREMENT OF SURFACE DOSES IN DIFFERENT BODY POSITIONS IN RADIATION INCIDENTS. Wachsmann, F. (Gesellschaft fuer Strahlenforschung m.b.H., Neuherberg bei Munich. Institut fuer Strahlenschutz). (In German).

The personal dose measured at one or more randomly selected sites of the body surface is strongly dependent on the radiation incidence direction and the dose distribution in space and is therefore a very inaccurate measurement for the actual burden in radiation exposed persons. The accurate knowledge of the dose distribution along the whole body is therefore necessary in order to estimate accurately the radiation burden and to initiate the necessary clinical precautions. Therefore it is necessary to measure the dose at various body sites, if possible up to 20 or more simultaneously. For this purpose a simple and cheap button dosimeter was described. This contains a phosphate glass dosimeter made energy independent with a compensation filter of lead. The results of phantom measurements with this button dosimeter were reported. (tr-auth)

**20008** (CONF-680507-, pp 249-51) DOSIMETRY OF IONIZING RADIATION USING LUMINESCENT DOSIMETERS. Delarue, R. (Societe Carbonisation Entreprise et Ceramique, Montrouge (France)). (In French).

After a description of the principle of dosimetry by radiophotoluminescent glasses, the concepts of the absorbed dose, exposure dose, and dose equivalent and the definitions of their measurement units, rads, roentgens, and rems, are summarized. The composi-

tion of a radiophotoluminescent glass with low Z is given and the modification of this composition in order to obtain a glass with gamma/thermal neutron equilibrated response was indicated. The various applications of luminescent dosimeters chiefly for civilian protection, are reviewed. (tr-auth)

**20009** (CONF-680507–, pp 257-62) RECENT DEVELOPMENTS IN SOLID STATE NEUTRON DOSIMETRY. Wik, Manuel; Dahlen, Goeran (Forsvarets Forskningsanstalt, Stockholm (Sweden)).

A fast-neutron dosimeter, consisting of a $P^+NN^+$ silicon diode has been developed. Irradiation causes permanent defects in the crystal lattice. As a result the forward voltage drop of the diode increases with increasing fast neutron exposure. The theory has previously been reported. Recently the accuracy of the measuring method, the resolution of the diode, its temperature dependence and fading effects have been studied as well as energy dependence, spread of initial voltage in the manufacturing process, spread of sensitivity for a specific type of diode and maximum neutron dose. (auth)

**20010** (CONF-680507–, pp 263-9) EQUIPMENT FOR RAPID DETERMINATIONS OF RESIDENCE TIME AVAILABLE IN RADIATION FIELD. Tschirf, E. (In German).

In the occupation of regions with high levels of gamma radiation by troops, the knowledge of the permissible residence time before the tolerance dose is exceeded is of great importance. The previously known methods permit a determination of this time only through numerical evaluation of dose output or dose measurements or make possible, with the help of a warning device, the registration of the absorption of a predetermined dose and therefore establish that the residence time has expired. In order to avoid the disadvantages of these methods and to obtain at each desired moment rapid and reliable information on the residence duration under the radiological conditions present, a radiation measurement device equipped for this purpose was used. The instrument is to be carried by persons occupied in the radiation region and with which the time until a predetermined tolerance dose can be determined by a direct scale reading. This time, indicated by t, can be determined by the equation $t = (D_v - D)/D_l$. $D_v$ is the tolerance dose, D is the dose up to the time of the measurement, and $D_l$ is the dose output. In principle, the instrument also contains a dose output and a dose measurement instrument. The construction of various residence time measurement devices, the interpretation of its range for special purposes, and proposals for its improvement and expansion are described. (tr-auth)

**20011** (CONF-680507–, pp 270-5) C.E.A. CERAMIC–THERMOLUMINESCENT MATERIAL DOSIMETER SYSTEM. Francois, H.; Pradel, J. (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires); Carpentier, S.; Delarue, R. (Societe Carbonisation Entreprise et Ceramique, Montrouge (France)). (In French).

A ceramic–thermoluminescent material dosimeter which is indestructible and can be incorporated in all types of construction is described. The thermoluminescent properties permit the evaluation of radiation doses by a non-specialized person. It can be applied to the ambient dosimetry and to zone dosimetry for civil defense purposes, dosimetry near reactors, etc. The material and its mode of use are described. The principal characteristics of the action of radiation on matter are given. (tr-auth)

**20012** BACKGROUND SUBTRACTION AND COMPENSATION OF CHANGES IN COUNTING RATE. Helbig, W.; Klein, P.; Beer, M. (Institut fuer Mechanisierung der Landwirtschaft, Potsdam, Ger.). Isotopenpraxis, 4: 472-3(Dec. 1968). (In German).

The design and properties of the high-dose counters VA-Z-261 and VA-Z-262 for $\gamma$ and $\beta$ dosimetry measurements are described. The electrode system in the coaxial arrangement consists of a molybdenum anode of 1 mm cross section and a chromium cathode of 4 mm cross section. Both types are filled with a rare-gas–halogen mixture. (L.B.S.)

**20013** IMPROVEMENTS IN OR RELATING TO MEASUREMENT OF LOW ENERGY $\gamma$-RADIATION. (to Gesellschaft fuer Kernforschung mbH). British Patent 1,146,646. Mar. 26, 1969. Priority date June 28, 1965, Germany.

A phosphate glass luminescent dosimeter system for measuring gamma radiation below 45 keV is described. Two similar dosimeters are covered with different absorbers to differentiate between dose due to gamma radiation above and below 45 keV. (W.H.K.)

**20014** A MODIFIED METHOD OF FERROUS SULFATE DOSIMETRY. I. Nakatsuka, Haruo (Osaka City Univ.); Hayashi, Chozo. Nippon Igaku Hoshasen Gakkai Zasshi, 27: 667-70 (Sept. 1967). (In Japanese).

A modified method of ferrous sulfate dosimetry was demonstrated. The reduction of the ferrous ions was measured as a Fe-TPTZ complex. The optimum pH of the dosimetry solution was determined to be 3.4 to 5.8. The change of the optical density of the Fe-TPTZ solution produced by x-irradiation was measured. There was observed an accurate linear relationship between radiation dose (450 R–3000 R) and the reduction of Fe-TPTZ. (auth)(NSA of Japan)

**20015** PHOTOGRAPHIC FILM DOSIMETRY. I. ON $\gamma$-RAY DOSIMETRY BY POSITIVE FILM. Okabe, Hirobumi; Furuhashi, Nobuyuki (Industrail Research Inst., Osaka). Osaka Furitsu Kogyo Shoreikan Hokoku, No. 41, 84-7(Apr. 1967). (In Japanese).

Photographic films are in wide use for monitoring personnel exposure due to x, $\gamma$, and $\beta$ radiation. The measurement of radiation dose can be made with positive film. The advantages are convenience, rapidness, and simplicity. By selecting developers of different concentrations and different developing times, film dosimeters cover a wide range of doses. Positive film is suitable for the measurement of radiation dose from 50 to $10^5$ R. Irradiations were carried out with $^{60}Co$, 500 Ci. Applications of this film for measuring the depth dose curve of scattered electrons is also studied. (auth)(NSA of Japan)

**20016** FILM DOSIMETRY FOR LARGE DOSE OF MONOENERGETIC ELECTRON BEAM BY POLYCARBONATE. Endo, Hitoko; Kami, Hisao (Industrial Research Inst., Osaka). Osaka Furitsu Kogyo Shoreikan Hokoku, No. 41, 88-91(Apr. 1967). (In Japanese).

Many reports have been devoted to research utilizing film dosimetry for ionizing radiation, yet no approved results were obtained concerning which kind of plastics would be suitable for measuring the dose of electron beams. Several films were examined for this purpose, and it was found that polycarbonate film of 0.075 mm thick gave a satisfactory linear relationship on a log-log plot between changes in optical densities at 330 m$\mu$ and absorbed energies covering a range from $10^6$ rad up to $10^8$ rad. (auth)(NSA of Japan)

**20017** DOSE DISTRIBUTION ANALYSER FOR FILM DOSIMETRY. Mori, Tomoyuki (Aichi Cancer Center Hospital, Japan); Nagai, Katsumi. Nippon Igaku Hoshasen Gakkai Zasshi, 27: 1587-91(Mar. 1968). (In Japanese).

A dose distribution analyzer using TV circuit was devised for easy application to film dosimetry. The TV circuit consists of an ordinary industrial TV, a picture monitor, slice circuit and a differential amplifier. Dose distributions obtained by this method differ slightly due to the variation of resolvability of the monitor picture compared with usual film dosimetry. However, for the purpose of clinical application, this measurement method may be convenient for the isodose patterns. (auth)(NSA of Japan)

**20018** FILM DOSIMETRY IN HIGH ENERGY ELECTRON THERAPY. Kitabatake, Takashi (Niigata Univ., Japan); Okumura, Yutaka. Nippon Igaku Hoshasen Gakkai Zasshi, 28: 1134-6(Nov. 1968). (In Japanese).

Energy and depth dependency in film dosimetry in high energy electron beam therapy was studied. Sakura gravure film Normal C was used for this purpose. In the energy ranges from 10 to 30 MeV with the same exposure, no evident variation of blackness was detected. The film characteristic curves obtained at the depth of 100%, 50%, and 20% dose distribution almost coincided, indicating no depth dependence. The error ranges of dose measurement were distributed between ±1%. It was concluded that the film dosimetry is reliable and valuable for practical use in high energy electron beam therapy. (auth)(NSA of Japan)

**20019** DOSIMETRY OF MEGAVOLTAGE X-RAYS AND ELECTRONS. Hiraoka, Takeshi; Habu, Takashi (National Inst. of Radiological Sciences, Chiba, Japan). Nippon Igaku Hoshasen Gakkai Zasshi, 27: 1315-22(Jan. 1968). (In Japanese).

When the ionization is measured in an air-filled cavity placed at a point in the irradiated medium, the absorbed dose in the medium may be estimated by means of the Bragg–Gray relation. In order to measure the cavity ionization, a thimble ionization chamber (cavity wall: 0.5 mm lucite, cavity volume: 0.681 cc) was developed. The performance test for the chamber was carried out for $^{60}Co$ $\gamma$-rays, 20 to 30 MV x rays and 10 to 30 MeV electrons. It has been confirmed that the stem leakage of the chamber is less than 0.2% of the cavity ionization, and the effect of the 0.5 mm lucite wall upon the cavity ionization is negligible in a water phantom. Since the conversion of the cavity ionization measured by the chamber into rads in the medium can be made by theoretical calculation, this chamber may be servicable for practical use. The response of several commercial dosemeters (R-scale) was investigated, and the rad-R conversion factor, that is the ratio of the absorbed dose as mea-

sured by this chamber at a specified point in the medium to the scale reading as measured by an R-dosemeter, is estimated for water. (auth)(NSA of Japan)

**20020** IMPROVEMENTS IN OR RELATING TO RADIATION INDICATORS. Dobo, Janos; Yi, Agnes Somog; Lakner, Endre (to Muanyagipari Kutato Intezet). British Patent 1,146,644. Mar. 26, 1969. Filed June 15, 1966.

An improved ionizing radiation detector is described, based on the use of polymers and acid sensitive dyes. It is stated that in such detectors as normally used the color changes are not sufficiently sharp and slight changes in illumination may introduce some degree of uncertainty in the color change. Visible light may also be sufficient to initiate photodecomposition, and cis-trans isomerization of the dye may cause the color of the indicator to shift in the absence of irradiation. Such detectors also do not give an indication of irradiation dose level. The detector described comprises an aqueous emulsion containing a polyvinyl chloride composition, an acid sensitive dye which is soluble in hydrocarbons and chlorinated hydrocarbons, and one or more additional dyes which are soluble in water but practically insoluble in hydrocarbons, these additional dyes having colors different from the acid color of the acid sensitive dye, and at least one of the additional dyes having a color different from the base color of the acid sensitive dye. The emulsion is deposited in the form of a film on a support. Detectors prepared in this way give color changes in several sharply distinguishable hues, according to the irradiation dose, and when used in conjunction with a calibrated color chart are suitable for rapid semi-quantitative estimation of irradiation dose. They are particularly suited for indicating doses in the range 0.05 to 1 MR, and are applicable up to 5 MR. The polymer composition may be a copolymer of vinyl chloride and vinylidene chloride; the acid sensitive dye may be p-dimethyl (or diethyl) amino-azobenzene. Additional dyes may include blue acidic fuchsine derivatives such as diphenyl-(or triphenyl-)p-rosaniline sulphonate), yellow pyrazolone type dyes such as Acid yellow 25 or Acid yellow 42. (UK)

**20021** DOSIMETER FOR MEASURING NEUTRON AND GAMMA RADIATION. Waly, Adnan; Just, Richard; Schwartzman, Leonard; Alster, David I. (to Electrospace Corp.). U. S. Patent 3,426,197. Feb. 4, 1969. Filed July 16, 1965.

A dosimeter for measuring both gamma and fast neutron radiation in which a cylindrical probe have a photoluminescent glass member and a silicon diode is carried within a casing is described. A lead shield is provided in the casing around the photoluminescent glass for equalizing its response. Windows in the probe admit ultraviolet light and permit emission of visible luminous light. The diode is provided with outwardly extending terminals to measure the neutron radiation by the application of an electrical current. (Offic. Gaz.)

**20022** THERMALLY STIMULATED EXOELECTRON EMISSION (TSEE) AS A METHOD FOR DOSE MEASUREMENTS USING LITHIUM FLUORIDE. Becker, K. (Oak Ridge National Lab., Tenn.). Health Phys., 16: 527-32(Apr. 1969).

Reference is made to the thermally stimulated emission of low energy electrons from the surface of irradiated LiF, which is an easily measured effect and can be used as a method of dosimetry by heating the irradiated sample inside a gas-flow GM counter. If the count rate during heating is recorded as a function of time or temperature, electron emission glow-curves are obtained, from which dose indications can be derived. The sensitivity of LiF TSEE dosimeters depends on a number of factors including concentration of detector material; area of detector; counter background; type of LiF; heat treatment of the material; and LET of the radiation. These factors are discussed. Data are given for the exoelectron emission of a LiF detector containing various amounts of graphite powder after exposure to $^{60}Co$ γ-radiation and, in one case, after exposure to alpha radiation from a Pu source. Fading data are also given, together with the relative sensitivities of various forms of LiF. It is pointed out that since TSEE is a surface effect, radiation interaction in extremely thin material layers can be studied. TSEE may also be considered as a semi-absolute type of dosimetry. The addition of carbon to the LiF reduces its energy dependence, and small additions of materials such as $CaSO_4$, $SrSO_4$, $BaSO_4$, $CaF_2$, etc. flatten the energy response. Mention is also made of LiF–BeO two-component systems and their uses. The dosimeters are completely annealed by the reading process, and are immediately ready for re-use without a complicated annealing procedure. (UK)

**20023** ON THE CAUSES OF CHANGES IN SENSITIVITY DUE TO RE-USE OF LiF THERMOLUMINESCENCE DOSIMETERS. Nakajima, Toshiyuki (National Inst. of Radiological Sciences, Chiba, Japan). Health Phys., 16: 509-14(Apr. 1969).

The LiF phosphors used in the investigations described were prepared by annealing at 600°C for 3000 min or more in argon gas and rapid cooling. When phosphors irradiated with $10^6$ R were annealed at 350°C for 30 min in argon gas, their pre-dose was ten times as great as the background noise of the electronic equipment, and their sensitivity was better than that of the original phosphors. After thermal treatment at 600°C for 30 min, however, the color centers of the phosphors disappeared and their pre-dose was reduced to the same order as the background noise. Optimum procedures of annealing for the recovery of the sensitivity of the phosphor are discussed. (auth)

**20024** PROPERTIES OF $CaSO_4$(Mn) POWDER FOR THERMOLUMINESCENCE DOSIMETER. Ikeya, Motoji; Itoh, Noriaki (Nagoya Univ., Japan). J. Nucl. Sci. Technol. (Tokyo), 6: 132-7(Mar. 1969).

Thermoluminescence and electron paramagnetic resonance (EPR) of $CaSO_4$(Mn) powder were studied. The intensities of the hyperfine lines in the EPR spectra of $Mn^{2+}$ and the heights of the thermoluminescence glow peak are found to change in parallel, upon varying the conditions of heat treatment and the concentration of $Mn^{2+}$. It is also found that $Mn^{2+}$ present in aggregate state, which gives a broad EPR spectrum, is not an effective activator for thermoluminescence; heat treatment at high temperatures serves to disperse this aggregated $Mn^{2+}$, which increases the thermoluminescence sensitivity. The relation between the thermoluminescence intensity and the radiation dose is linear, so long as the duration of irradiation is within certain limits; the deviation from the linear relation is explained in terms of fading of thermoluminescence at the temperature of irradiation. (auth)

**20025** EFFECT OF PARTICLE SIZE ON THE THERMOLUMINESCENCE OF LITHIUM FLUORIDE. Burlin, T. E. (Regent Polytechnic, London); Chan, F. K.; Zanelli, G. D.; Spiers, F. W. Nature (London), 221: 1047-8(Mar. 15, 1969).

It has been reported that the luminescence efficiency of LiF varies with particle size, and it has been suggested that the cause could be the presence of an inactive surface layer. Further studies are described on the variation in luminescence efficiency of small particles with photon energy, and a further factor is discussed which could, in some circumstances, lead to a decrease in response for small particle sizes. The energy actually deposited in a grain of LiF depends on the energy balance between the sum of the energies of the electrons leaving the grain and the sum of the energies of the electrons generated within the grain and entering it from the surrounding medium. The total electron energy entering a grain will depend on the mass energy absorption coefficient of the material surrounding the grain (usually air), whereas the total electron energy generated within the grain will depend on the mass energy absorption coefficient of the LiF. Factors which apply if the grains are isolated from one another with gaps of the same order as the electron ranges in air are discussed. These include the dominant Compton absorption process for photon energies above 0.15 MeV; for this energy there is no difference in the energy deposited per unit mass in grains of different sizes, and hence no difference in their luminescence on heating. At lower photon energies (e.g., 0.03 MeV) photoelectric absorption is the chief process, which is strongly dependent on atomic number. Since LiF has an effective atomic number higher than that of air, more energy is carried out by electrons leaving a grain than is brought in by electrons entering the grain from the surrounding air, and the magnitude of the energy imbalance depends on particle size; the smaller particles are most influenced by such surface effects, and their luminescence on heating is most reduced. At still lower photon energies (e.g., 0.01 MeV) the range of the photoelectrons becomes so small that these surface effects become of minor importance for all grain sizes. Consideration must also be given to the differences in stopping power for electrons in air and LiF, and also to the energy dependence of the electron stopping power. Measurements are described of the response of LiF of two different grain sizes to monoenergetic x-rays of various energies. It is concluded, however, that energy imbalance alone, between LiF and the surrounding medium, cannot be the major cause of the observed reduction in light output by fine grain LiF. Some intrinsic cause, possibly associated with surface layer effects, seems to be implied. (UK)

**20026** IMPROVEMENTS IN AND RELATING TO MEASURING INSTRUMENTS FOR USE WITH A THERMO-LUMINESCENT DOSIMETER. (to Manufacture Belge de Lampes et de Materiel Electronique, MBLE). British Patent 1,147,655. Apr. 2, 1969. Priority date Oct. 1, 1965, Belgium.

A circuit for measuring the peak voltage from a readout photocell for a thermoluminescent dosimeter is described. (W.H.K.)

## Radiometric Instruments

*Refer also to abstracts 19691 and 19916.*

**20027** (CEA-CONF-1187) ESTIMATE OF POSSIBILITIES OF $\gamma$-$\gamma$ RADIO CORE SAMPLING. [Dumesnil, P.] (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Feb. 21, 1968. 16p. (In French). (CONF-680213-1). Dep.

From Conference on Display of Information for Foreign Engineers, Razes, France.

The principle of $\gamma$-$\gamma$ density measurement is described, and a practical method for the determination of the energy threshold is given. The application of the method to uranium ores is discussed. The field studies made with the radio core sampling method are described. A precision of about 15% was deduced. (J.S.R.)

**20028** PORTABLE $^{170}$Tm DEVICE FOR GAMMA INSPECTION OF LIGHT METALS. Penteado Filho, A. C.; Sanchez, W. Metalurgia (Sao Paulo), 24: 425-32(June 1968). (In Portuguese).

A device which operates on a $^{170}$Tm source and is suitable for industrial inspection purposes has been designed and built in Brazil. Its design, operation, and the operating characteristics deduced from trial inspections of Al welds are described. These trials have shown that $\gamma$ radiation from $^{170}$Tm is capable of producing radiographs equivalent to those produced by a 100-kV x-ray unit. The best results were obtained on thicknesses of 6–20 mm, using fine-grained films. In this thickness range, 2% sensitivity was obtained by using a radiographic density of 0.7 to 1.0. The irradiator used in the trials is suitable for $^{170}$Tm sources with activities to 4 Ci. Another, for $^{170}$Tm sources of about 8 Ci or $^{192}$Ir sources of approximately 2–3 Ci, has also been designed. Diagrams of both are shown. Background information is given on the use of $\gamma$ radiation as an inspection tool and on operator safety. The entire unit described (irradiator, source and shielding) is said to cost about one-tenth of the price of a 100-kV industrial x-ray machine. (Metals Abstr.)

**20029** NUCLEAR GAGING SYSTEM FOR MOISTURE CONTENT OF IRREGULAR STREAM OF BULK MATERIAL. Stone, Leonard R.; Reim, Thomas E.; Muskovac, Nicholas G.; Cook, James E. (to Republic Steel Corp.). U. S. Patent 3,431,415. Mar. 4, 1969. Filed Feb. 17, 1967.

There is disclosed a bulk material moisture gaging system having a source of fast neutron and gamma radiation for irradiation of substantially an entire cross-sectional volume of a bulk substance moving in a confined stream of irregular and varying cross section independently of the cross-sectional geometry of the stream. Means responsive to slow neutrons from the cross-sectional volume irradiated by neutrons derive a first electrical control energy varying with the moisture content of an irradiation volume of the substance and means responsive to gamma radiation from the cross-sectional volume irradiated by gamma radiation derive a second electrical control energy varying with the mass of said substance in an irradiation volume thereof. Finally, means jointly responsive to the first and second electrical control energies obtain the ratio existing between the first and second control energies and generate an output signal proportional to the weight percentage moisture content of the substance substantially independently of the geometry of the material in the stream of material being gaged. Mechanism is provided for withdrawing the radiant source holder and the detectors from gaging position to an inactive calibrating position for periodically calibrating the system in reference to mobile calibration blocks movable into and out of the gaging zone between source and detector. (Offic. Gaz.)

**20030** MEASUREMENT OF SEQUENTIAL VARIATIONS OF WATER CONTENT OF SOILS. Lorch, S. (Alfred-Bentz-Haus, Hanover). Z. Geophys., 33: 403-14(Dec. 1967). (In German).

A method for measurement of soil water concentrations is described and the results are discussed. The physical characteristics of a source of $\gamma$ radiation and a detector are described and the mathematical basis for the method used are outlined. The measurement errors and the results obtained from several types of soils are presented. The results demonstrate the feasibility of measuring very small variations in water content in soils and the method discriminates differences between soil layers horizontally. The over-all error of the system is 0.0023 g/cm$^3$. Corrections introduced into the measurement procedure facilitate evaluation of the water content of the soil surface layer where scattered radiation increases measurement inaccuracies. (BBB)

**20031** RADIATION-TYPE INTERFACE DETECTOR. (to Universal Oil Products Co.). British Patent 1,145,332. Mar. 12, 1969. Priority date May, 10, 1965, United States.

A radiometric system for detecting liquid–liquid interfaces, vapor–liquid interfaces (liquid level) or gas–solid interfaces (solids level) is described. A conduit is located vertically in the vessel so that a radiation source may be raised or lowered to any level in the vessel. A radiation detector is located outside the vessel. A drive system is designed to simultaneously move the radiation source and detector up and down to detect interfaces in the vessel. (W.H.K.)

**20032** A METHOD OF MEASUREMENT OF PHYSICAL MAGNITUDES. Duftschmid, Klaus E.; Foltyn, Erich; Steidl, Johannes; Patzelt, Rupert; Attwenger, Wolfgang (to Oesterreichische Studiengesellschaft fuer Atomenergie GesmbH). British Patent 1,145,562. Mar. 19, 1969. Priority date Mar. 19, 1965, Austria.

A radiometric gage for measuring thickness, weight per unit area, density, or radiation absorption by materials is described. A comparison absorber is used for calculations. (W.H.K.)

**20033** RADIATION THICKNESS METER. Hirayama, Tsutomu (to Yokogawa Electric Works, Ltd.). Japanese Patent 1968-29670. Dec. 5, 1968. Filed Oct. 29, 1965.

By the method proposed, the distance between a radiation-source container and an ionization chamber, in the radiation thickness meter, can be kept always constant. Along the two horizontal beams, one above the other, in the O-shaped frame of the radiation thickness meter, relatively short rods of square cross-section are aligned horizontally. Between the two rods, a device is installed for moving the two rods up or down, thereby making it possible to keep the distance constant between the radiation source and the ionization chamber. (NSA of Japan)

**20034** APPARATUS FOR DETERMINING WALL THICKNESS UTILIZING RADIATION ABSORPTION. O'Shea, Christopher J.; Quinn, Richard; Johnson, Donald S. Jr. (to Ball Brothers Research Corp.). U. S. Patent 3,426,196. Feb. 4, 1969. Filed Feb. 21, 1967.

An apparatus for testing wall thickness wherein a pulse output is produced by a radiation detector situated at the side of the wall to be tested opposite to that of a radiation source is described. The produced pulse output is coupled to a pulse discriminator that generates pulses of both constant amplitude and width which are then utilized to produce an analog voltage signal which triggers a reject circuit when the level exceeds a predetermined value. (Offic. Gaz.)

**20035** ASH CONTENT METER USING RADIATION. Mizukoshi, Tsutomu; Terai, Etsuji (Fujitsu Ltd., Japan). Fujitsu, 20: 109-17(Jan. 1969). (In Japanese).

Along with the present development of the petroleum industry and atomic industry, the coal industry has to be even more rationalized; nearly 10% of the domestic energy consumption in Japan is dependent upon the coal. Guarantee of the coal quality at a reasonable level is one of the most important problems to solve for the industry, Therefore, there has been an increasing demand to measure, quickly and on-line the ash content, which is dependent to the calorie. The conventional ash content measuring method is the combustion method which is the sampling and destructive system therefore needs longer time and sampling error is greater. In order to eliminate these defects, an ash content meter using x-ray transmission and reflection was developed; thus it makes possible the on-line measurement. However, the equipment is expensive and requires a complexity in mechanism and control, and it lacks stability; for these reasons, the equipment is not yet commercialized in Japan. Fujitsu Limited has successfully developed an ash content meter which uses absorption of the $\gamma$-ray under close cooperation of the Institute of Coal Technology and the above-stated defects are eliminated. The equipment has been on-line operation after a commercializing test. This ash content meter uses americium-241 and cesium-137 for the radiation source, and is based on the principle that the coal consists of two components, combustion component and ash component and absorption of $\gamma$-ray by the americium varies depending on them. However, the measurement done only by the americium affects the bulk density of the coal in the on-line system, and the errors arise. Therefore, the cesium $\gamma$-ray (660 keV) is used to measure bulk density. Both the outputs, (cesium and americium channel) are calculated so that the ash content can be measured without being affected by the bulk density. This ash content meter features the following: noncontact and nondestructive measurement, no sampling error, different from the combustion method by the sampling, and the ash content value can be directly read and recorded in the electronic recorder, then very convenient for process control. The output can be used for application to the automatic control in the on-line system. (auth) (NSA of Japan)

## Miscellaneous Instruments and Components

*Refer also to abstracts 20978, 21252, 21253, and 21331.*

**20036** (AD-674418) A RADIOISOTOPE X-RAY FLUORESCENCE SPECTROMETER WITH A HIGH-RESOLUTION SEMICONDUCTOR DETECTOR: DETERMINATION OF ANALYTICAL SENSITIVITY. Yamamoto, Sachio (Naval Radiological Defense Lab., San Francisco, Calif.). May 12, 1968. 30p. (USNRDL-TR-68-77). CFSTI.

The analytical sensitivity of an x-ray fluorescence spectrometer utilizing a radioisotope exciter source and a high-resolution, lithium-drifted silicon detector was evaluated. The spectrometer system which was studied used 1125 as the exciter source and contained a 30 sq mm detector with a resolution of 512 eV full-width at half-maximum (fwhm) at 6.40 keV. Known molybdenum samples ranging from 10 nanograms to 1 milligram and nickel samples ranging from 0.1 microgram to 1 milligram were prepared and analyzed. It was found that the detection limit for molybdenum was 35 nanograms with a ca 5 mc exciter source; precision in the submicrogram range was 10–20%. The detection limit for nickel was considerably poorer and was found to be 1 microgram for an exciter source strength of ca 10 mc. An examination of the various factors that affect the analytical sensitivity of the system showed that the sensitivity was limited primarily by poor detector geometry resulting from the small size of the high-resolution Si (Li) detector, and background. A principal contributor to background was backscatter of the exciter source radiation by materials surrounding the source and detector. It was found that the radiation was being scattered mainly by air. (auth) (USGRDR)

**20037** (AD-674748) MASS SELECTOR FOR ION BEAM EXPERIMENTS. Research Communication No. 61. Theard, Lowell P. (Douglas Aircraft Co., Inc., Huntington Beach, Calif. Advanced Research Lab.). June 1968. 45p. (DAC-5047). CFSTI.

A mass selector which efficiently produces mass filtered beams of both primary and secondary ions in the medium current ranges is described. Currents up to 0.000001 A for the mass filtered beam can be obtained with beam energies of 3 to 5 keV. Ions are produced in a hot-cathode gas discharge ion source of relatively simple construction and are extracted as a parallel beam. Mass analysis is accomplished over a short path length with a compact, high-current, sector-field electromagnet which is entirely contained within the analyzer chamber. An electrostatic quadrupole lens is used for optimum shaping of the incident ion beam for high transmission through the magnetic sector. A second quadrupole lens, used to restore parallelism to the mass filtered ion beam, is mounted beyond the image slit, which was made wide enough to pass the entire image focused beam. The instrument has no object slit, as the entire incident beam is brought to a crossover at the object position. Beam transmission through all elements in the analyzer chamber, including the two quadrupole lenses, the sector magnet, and the image slit, is approximately 50%. Oscillating beam scanners are used to measure the beam density profile and to monitor the mass spectrum. The resolving power for spatial separation is about 60. Secondary ions such as N4(+) and CH5(+) can be generated with intensities comparable to those of primary ions. (auth) (USGRDR)

**20038** (BNWL-911) FEASIBILITY STUDY OF PROBE-TYPE LIQUID METAL FLOWMETERS FOR FTR SUBASSEMBLIES. Libby, H. L.; Jensen, J. D. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Feb. 1969. Contract AT(45-1)-1830. 52p. Dep. CFSTI.

Results of a feasibility study of probe-type liquid metal flowmeters are presented. A comparison of inside-channel eddy current flowmeters and inside-channel eddy current ultrasonic flowmeters indicates that the eddy current flowmeter is most suitable for the proposed application in the FTR subassemblies. Experimental results using liquid Wood's alloy as the liquid metal medium indicate a sensitivity of 18 μV/ft/sec velocity per volt bridge drive for a 1 in. diameter eddy current probe. Low impedance makes the eddy current probe compatible with cabling able to withstand radiation levels encountered in the reactor environment. (auth)

**20039** (CEA-CONF-1180) PROPOSED SYSTEM FOR ON-LINE INFORMATION PROCESSING INCLUDING SEVERAL HIERARCHICAL POSTINGS. Labbe, J.; Fernier, Ph.; Laget, J. P. ([Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires]). [1967]. 14p. (In French). (CONF-680906-18). Dep.

From International Symposium on Nuclear Electronics, Versailles, France.

A design for an on-line information processing system is proposed which separates the functions of acquisition and exploitation. The acquisition is done by satellite postings of simplified configurations connected with a central posting. This centralizes the results of the measurements and assures the processing. The principle of the system is discussed in some detail. The characteristics of the acquisition and exploitation postings are given. (J.S.R.)

**20040** (CEA-CONF-1188) PROGRAM FOR ACQUISITION AND TREATMENT OF NUCLEAR INFORMATION. Barthelemy, M. M. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). June 7, 1968. 21p. (In French). (CONF-680642-1). Dep.

From International Conference on Electronics and Automation, Herceg Novi, Yugoslavia.

The development of an analysis system incorporating a digital computer, designed particularly for use in nuclear physics, was described. The system is designed to assure the functions of acquisition, analysis, display, and storage of experimental data. It can also be used for the control of experimental devices to which it is connected. Each component of the analysis system is described. The system is organized around the central computer DATA 620 I. The essential characteristics of the fast coupler, the slow coupler, and the display unit are outlined. The principles to be followed in the programming of the system are summarized. (J.S.R.)

**20041** (COO-913-32) DESIGN OF A LOW ENERGY ELECTRON IMPACT SPECTROMETER. Swanson, Adrian; Lipsky, Sanford (Minnesota Univ., Minneapolis. Dept. of Chemistry). Mar. 1, 1969. Contract AT(11-1)-913. 33p. Dep. CFSTI.

A spectrometer used to identify low lying triplet states of polyatomic molecules and to study the threshold behavior of their scattering cross sections is described. The physical phenomenon observed is the energy loss suffered by a nearly monoenergetic beam of electrons incident on a static target gas. The target gas is confined to a small scattering chamber at the center of the spectrometer into which the incident beam is projected. Two electron energy analyzers are mounted adjacent to the scattering chamber and have their entrance apertures oriented at 0 degrees and 90 degrees with respect to the incident beam. The entire spectrometer is housed in a mercury pumped, cold trapped, bakeable, ultra-high vacuum chamber. Internal radiant heaters maintain uniform spectrometer and scattering chamber temperatures up to about 150 degrees centigrade during operation. (auth)

**20042** (INR-954) A PRELIMINARY STUDY ON THE A.C. BRIDGE LEVEL SENSOR FOR LIQUID METALS. Dzedzits, Ya. (Institute of Nuclear Research, Warsaw (Poland)). 1968. 17p. (In Russian). Dep.

The design of a new type of continuous level gauge for liquid alkali metals in containers is described. An original measurement method is described, based on the basic symmetrical bridge circuit but with closely (100%) inductively coupled opposite arms and (~50%) coupled adjacent arms. Measurements performed on the gage model have confirmed, that the predictions and theoretical considerations were correct. In consequence a prototype of this simple device has been obtained with a very high sensitivity and low temperature dependence. The complete level indicator with this sensor does not need electronic devices and is supplied with 50 + 60 c/sec power network. These features may be considered as two additional advantages of the device. (auth)

**20043** (MATT-562) AN AUTOMATICALLY SWEPT PHOTOELECTRIC FABRY-PEROT SPECTROMETER. Hirschberg, Joseph G.; Wilson, Ernest L. (Princeton Univ., N. J. Plasma Physics Lab.). Nov. 1968. Contract AT(30-1)-1238. 62p. Dep. CFSTI.

A pressure-swept photoelectric Fabry-Perot interferometer is shown to be the most advantageous instrument under certain conditions for line breadth measurements. Fabry-Perot theory is summarized, and attention is paid to the choice of the various parameters, mirror reflectivity, intermirror distance, plate flatness, and exit orifice size. Adjustment, calibration, and measurement are described. (auth)

**20044** (N-68-34487) QUADRUPOLE IONIZATION GAUGE. Schwarz, Helmut (Rensselaer Polytechnic Inst. of Connecticut, Inc., East Windsor Hill. Hartford Graduate Center). Apr. 1968. 14p. (NASA-CR-96818; CONF-680401-6). CFSTI.

From 4th General Meeting on International Organization for Vacuum Science and Technology, Manchester, England.

The difference between the Penning gauge and the new ionization

gauge lies mainly in the fact that the confinement of the electrons is achieved by electrostatic quadrupole lenses instead of a magnetic field. Electrons are emitted from a hot cathode at one end of the tube and accelerated along the tube. They then encounter an inverted field which causes the electrons to return and continue to oscillate obtaining maximum velocity each time they pass the middle of the tube. The produced ions are collected by a cylindrical screen surrounding the whole electrode structure and/or the flat disc. The tube can be operated in two modes: dc potentials or ultra high frequency are applied to the quadrupole rods. In the case of the dc operation, the sensitivity factor was 10 and in the high frequency operation more than 2,000 times higher than that of a regular Bayard–Alpert gauge. The x-ray limit is so low that it plays a lesser role than adsorption and desorption phenomena at the ion collector. Adsorption and desorption processes come to an equilibrium in front of the ion collector and create a kind of gas cloud. (auth) (STAR)

**20045** (N–68–36738) A MULTIPOINT FIELD IONIZATION SOURCE. Final Report, November 11, 1966–April 12, 1968. Hoenig, Stuart A.; Farwell, William (Arizona Univ., Tucson. Field Emission and Space Systems Lab.). Apr. 12, 1968. Contracts NAS-7-100; JPL-951560. 28p. (NASA-CR-97221). CFSTI. For Jet Propulsion Lab., Pasadena, Calif.

An investigation was made of the use of field ionization and field emitted electrons as ion sources for use with a quadrupole mass spectrometer. It has been possible to replace the normal filament type electron source with a field emission electron source in the form of a 100-point comb. Results with this source have been very satisfactory. The electrons generate a normal bombardment ion spectrum. Operation of this comb as a direct field ion source showed that such source cannot be used for direct injection into a quadrupole type mass spectrometer. The requirements for low energy ions and a straight-through geometry are too severe. It is planned to install an energy analyzer to swing the ion beam about 100° in order to obtain better control and focusing of the ions as they enter the spectrometer and to aid in removal of the high energy electrons and neutrals which introduce high noise levels. (auth) (STAR)

**20046** (NP-tr-1736) REVERSIBLE DECADES BUILT WITH FAST DTL ELEMENTS. Sawicki, A. Translated by S. Jaroslawski for Atomic Energy Research Establishment, Harwell, Eng., from Przegl. Telekomun., 38: 104-8(1966). 17p. Dep.

The realization of reversible binary counting is discussed, and the principle of forcing reversible decimal counting into a four bit system is described. Two diagrams of reversible decades built with universal DTL components are presented, and their advantages and disadvantages are discussed. (auth)

**20047** (PEL–184) TRANSMIT: A COMPUTER PROGRAM TO EVALUATE A MULTI-ELECTRODE ELECTRON GUN. Haarhoff, P. C.; Krige, G. J.; Gordon, S. M. (Atomic Energy Board, Pelindaba, Pretoria (South Africa)). Nov. 1968. 67p. Dep.

A computer program, based on a model of a multi-electrode electron gun, suitable for theoretical studies of Retarding Potential Difference (RPD) guns is described. The effect of the spiralling motion of electrons and of the spread in their initial energy on the properties of electron guns is fully taken into account, assuming homogeneous electrical fields between slits and negligible space charge effects. Examples of the application of the program are given. (auth)

**20048** DESIGN AND PROPERTIES OF THE HIGH-LEVEL COUNTERS VA-Z-261 AND VA-Z-262. Bartho, H. (VEB Vakutronik, Dresden). Isotopenpraxis, 4: 474-6(Dec. 1968). (In German).

A simple modification to counters (e.g., VA M 14, 15, 16) equipped with decade counter tubes is described which corrects for the background when the sensitivity of the measuring instrument changes, or when the results are to be compared with several measurements. The circuit diagram and the operation are described. (L.B.S.)

**20049** MASS SPECTROMETER AS A RADIOLYTIC AND CATALYTIC LABORATORY. Melton, Charles E. (Univ. of Georgia, Athens). J. Mass. Spectrom. Ion Phys., 1: 353-75 (Oct. 1968).

From its inauspicious beginning more than half a century ago, the mass spectrometer has evolved to a stage where it can be used as a complete self-contained laboratory for catalytic and radiolytic studies. In a specific application, the first step is to select the proper type of ion source. Four different types of specialized ion sources are described briefly and an application of each of these sources to a representative problem is given. For a problem in radiation chemistry, the elementary steps of the reaction can be followed in temporal sequence from about $10^{-14}$ sec after irradiation until final products appear. Both types can be studied. Developments in mass spectrometry, however, have not eliminated the need for other scientific instrumentation. Instead, the mass spectrometer is often used in conjunction with other instruments to extend the domain of each. (BBB)

**20050** USE OF MULTICHANNEL ANALYZERS IN THE BIOMEDICAL FIELD. Gillespie, Frank C. (Western Regional Hospital Board, Glasgow). Bio-Med. Eng., 2: 484-7(Nov. 1967).

The modes of operation and limitations of multichannel analyzers are indicated and their versatility for applications in the biomedical field are discussed. The instrument components, including an analog-to-digital converter, an address register, a store memory, a display which indicates the contents of the memory, and a device that permanently records the contents of the memory are described briefly, and their functions and operations are outlined. The applications of the multichannel analyzer, including pulse-height analysis of signals from particle detectors, pulse-height analysis of other signals, periodic sampling of slowly varying signals, and the multiscaler mode of operation are described. These are illustrated by examples, and typical results of data sampling in these modes are discussed. (BBB)

**20051** EXTENDED RANGE GAPS (Engineering Materials). (General Electric Co., St. Petersburg, Fla. Pinellas Peninsula Plant). (CAPE–1842).

184 drawings.

Two (10 kV and 30 kV) cold cathode switching devices requiring no keep-alive input power and no warm-up time are described. The switching device is used with a low stable time delay, a wide operating voltage range, and high current rise. It is capable of switching up to several thousand A with low time jitter and delay over an operating range of <3000 V to 30,000 V. (For details see TID-4100, Suppl. 51; see also NSA 23: 9378) (F.S.)

**20052** ANALYSIS OF INTEGRATED CHARGED PARTICLE ENERGY SPECTRA FROM GRIDDED ELECTROSTATIC ANALYZERS. Roth, J. Reece (Lewis Research Center, Cleveland); Clark, Marion. Plasma Phys., 11: 131-43(Feb. 1969).

The shape of the retarding potential curve produced by gridded electrostatic analyzers is related to the floating potential, the kinetic temperature, and the half-angle subtended in velocity space by the particles. Special emphasis is placed on the case in which the particles are Maxwellianized but restricted within a loss cone in velocity space of half-angle $\theta_0$. The cases of pulsed and steady-state supply of particles are both considered. By using an appropriate computer program to compare the analytical expressions derived herein with experimental retarding potential curves, one may obtain significantly more information about the velocity distribution than is possible with conventional methods of data reduction. A series of illustrative experimental runs is reduced with a computer program, and the magnitude of run-to-run variations is discussed. (auth)

**20053** MASS SPECTROSCOPES HAVING MEANS FOR FOCUSING THE ION BEAM IN SYNCHRONISM WITH THE SCANNING VOLTAGE. Brunnee, Curt; Kappus, Guenter (to Atlas Meb- and Analysentechnik GmbH). U. S. Patent 3,426,192. Feb. 4, 1969. Filed Sept. 3, 1965.

A mass spectroscope having an exit slit through which ions leave the ion source and follow a circular path determined by the ion source acceleration voltage toward one of two separated entrance slits is described. A split lens electrode for focusing the ion beam upon the exit slit has a predetermined potential difference across the two lens halves to deflect the ion beam so that it passes through the exit slit. This potential difference is varied in accordance with the acceleration potential so that regardless of the mass range being scanned, ions within that mass range are always emitted through the exit slit. (Offic. Gaz.)

**20054** IMPROVEMENTS IN OR RELATING TO FLUID LEVEL LOCATIONS. Liddiard, Francis Ernest; Heath, James Henry (to United Kingdom Atomic Energy Authority). British Patent 1,145,985. Mar. 19, 1969. Filed Sept. 17, 1965.

The apparatus described comprises an electromagnetic microwave source (klystron), a transmission line for projection through the fluid surface and arranged so that the radiation from the source and its reflection from the fluid surface establish standing wave patterns in the line, and a phase comparator for determining the phase displacement of the reflected microwaves with respect to the source in order to give an indication of the position of the fluid surface. The phase comparator comprises a counting circuit to determine the number of half wavelength positional changes,

a micrometer means for detecting the phase displacement corresponding to fractional parts of a half wavelength, and means for regulating whether said number is to increase or reduce the count indicated in accordance with the sense of movement of the fluid surface. An application is to the measurement of the level of heavy water moderator in a nuclear reactor. (UK)

**20055** LOGIC CIRCUITS. Schulze, Hans (to VEB Elektro-Apparate-Werke Berlin Treptow). British Patent 1,145,878. Mar. 19, 1969. Filed May 12, 1966.

A fail-safe gate circuit is described which includes a transistor (or transistors) two electrodes of which are subject to steady state binary input signals and the third electrode to a pulse signal. The circuit is suitable for nuclear reactor control purposes. The pulse signal is used at the circuit output as an information carrier. The circuit may be arranged in series combination so that resistors for the input signals and voltage dividers for the pulse signal are dimensioned and arranged in such a manner that the pulse signal undergoes considerable attenuation, so that in the event of defect in any one transistor the next in circuit is not rendered conductive. The base electrodes of the transistors may be biased by means of non-linear components. Resistor or diode decoupling elements may be provided in the output of each circuit in the combination. The output signals may also be decoupled by a push-pull connected transformer, two halves of the transformer primary winding being subjected to pulse trains out of phase by 180°, and each half of the primary winding being energised in such a way that the resulting output signal in the secondary winding is sufficient, when a working signal is required, to operate a subsequent control element, even if, owing to a defect in one half of the primary winding or in one of the preceding transistor circuits, the relevant half of the winding plays no part in the operation of the transformer. (UK)

**20056** THE MEASUREMENT OF RADIOACTIVITY IN LIQUID SAMPLES WITH A MODIFIED MARINELLI BEAKER. Meijers, C. A. M.; Dalessi, J. J. Th. (St. Annaziekenhuis, Geldrop, Netherlands). Clin. Chim. Acta, 22: 456-7(Nov. 1968).

Even with a flat crystal detector, it is possible to measure with great sensitivity, the radioactivity in liquid samples, using a Marinelli beaker. A Marinelli flow-cell was constructed which has the following advantages: (1) suction system: the apparatus is filled to a constant level that is controlled by the top suction outlet. After measuring the radioactivity, the cell is emptied by the bottom suction outlet; (2) effective geometry, caused by a small volume-area ratio; and (3) excellent reproducibility of the measurement. To exclude contamination of radioactive material at the walls (made of Perspex) of the flow-cell, the samples are diluted with R.B.S.-25 to a final concentration of 2%. The sensitivity and linearity obtained by this system, using $^{131}I$, are illustrated. (BBB)

**20057** ELECTRONICS ASSOCIATED WITH A TRIPARAMETRIC MEASUREMENT IN NUCLEAR PHYSICS. Graf, Erhard (Univ., Neuchatel, Switzerland). Z. Angew. Math. Phys., 20: 113-27(Jan. 25, 1969). (In French).

A three-parameter system that was developed for studies of the reaction $n + d \rightarrow n + n + p$ at 14 MeV is described in detail. (D.C.W.)

**20058** SOME APPLICATIONS OF ANALOG-DIGITAL CONVERTERS IN NUCLEAR, BIOLOGICAL, MEDICAL, AND GEOPHYSICAL RESEARCH. Biri, J.; Blasovszky, M.; Tarnay, K. Meres Automat., 15: No. 1, 17-21(1967). (In Hungarian).

The analog-digital converters used in nuclear, biological, medical, and geophysical research permit the high precision digitalization of various analog quantities. The following measuring methods are discussed: particle energy distribution measurement, determination of the absorption lines for Moessbauer-effect, measurement of slow neutron energy spectra, digital oscilloscope operation, digital averaging of events with a large background noise, angular correlation experiments, and energy correlation measurements for cascade decay. (auth)

**20059** PULSE ATTENUATOR WITH VERY SMALL VARIATION IN TRANSIT TIME. Bernaudin, Ph.; Bosshard, R.; Zajde, C. (Ecole Normale Superieure, Orsay, France). Nucl. Instrum. Methods, 68: 347-50(Feb. 15, 1969). (In French).

A fast 50 Ω pulse attenuator built with lumped components is described. The compensation of residual inductances was achieved by the use of distributed capacitance. The rise-time for an attenuation of 31 dB is less than 0.5 ns, the total transit time is about 1.2 ns and the variation of this delay vs the attenuation is less than 100 ps, whatever the attenuation. In fact this variation of the delay measured at half height of the signal is related to the degradation of the rise-time. This circuit is very useful for fast coincidence setups. (auth)

**20060** ELECTROSTATIC FIELD ANALYSIS AND DEVELOPMENT OF A GRID FOR RADIOFREQUENCY MASS SPECTROMETERS. Lall, H. B.; Gill, P. S. (Central Scientific Instruments Organization, Chandigarh, India). Nucl. Instrum. Methods, 68: 188-96(Feb. 15, 1969).

The role of the grid in an rf mass analyzer is examined. An approximate solution for the electrostatic field of a grid is obtained. The conditions for minimum field distortion and comparatively higher ionic transmission coefficient have been derived. Approximate field configuration and potential distribution within a square grid-pitch have been obtained. The effect of the grid-micro-optics on the performance of the rf mass analyzer has been discussed. Grids with better micro-optics and efficiency have been developed for use in an rf mass spectrometer. (auth)

**20061** RADIOFREQUENCY MASS ANALYZER TUBE FOR USE AS DIFFERENT TYPES OF NON-MAGNETIC MASS SPECTROMETERS. Lall, H. B.; Gill, P. S. (Central Scientific Instruments Organization, Chandigarh, India). Nucl. Instrum. Methods, 68: 197-204(Feb. 15, 1969).

A description is given of the development of an rf mass analyzer-tube which can be employed for use as Bennett-type aperiodic rf mass analyzer, as a time-of-flight mass spectrometer, as a time-of-flight mass spectrometer with parabolic path, as a Redhead type rf mass spectrometer and as a resonance mass selector, after making a slight adjustment of the grids in the analyzer assembly. A novel method of electrode mounting has been achieved. Fine and accurate grids of special configuration with improved micro-optics have been developed for use in the analyzer. This mass analyzer tube provides a most simple and convenient technique for the comparison of performance and operating characteristics of various types of non-magnetic mass analyzers under the same operating conditions. (auth)

**20062** VOLTAGE EFFICIENCY OF SCHENKEL-TYPE VOLTAGE MULTIPLIER CIRCUIT. Hara, E. (Hitachi Central Research Lab., Tokyo). Nucl. Instrum. Methods, 68: 251-5(Feb. 15, 1969).

The Schenkel type voltage multiplier circuit cannot be divided into four-terminal networks. Therefore the transmission line theory, by the aid of which the voltage efficiency for the Cockcroft–Walton type voltage multiplier circuit is obtained, cannot be applied directly. However, it can be proved that the voltages and currents distributed in the Schenkel type voltage multiplier circuit can be separated into two components, one of which is independent of the position of stage and the other, which depends on it, can be calculated by using the transmission line theory applied to mathematically equivalent hypothetical four-terminal networks. Voltage distribution on rectifiers connected in series and voltage efficiency obtained by this method are calculated numerically for some typical circuit constants. (auth)

**20063** AN EXTERNAL BEAM-PULSING SYSTEM FOR PRODUCTION OF PULSED 4-MeV ION BEAMS OF 0.5 nsec DURATION. Kornahl, W.; Richter, F. W. (Univ., Marburg, Ger.). Nucl. Instrum. Methods, 68: 298-314(Feb. 15, 1969). (In German).

An external beam-pulsing system is described which is able to chop pulses of 0.15 ns duration from a 4-MeV proton beam by sweeping it with radiofrequencies of 32 and 4 MHz across a limiting aperture. In the first of the three main parts the beam-deflecting method with respect to the production of very short ion-pulses is discussed in general. The second part reports on some theoretical investigations and calculations which had been done in order to find an optimal parameter set for the outline of the pulsing-system. The last part gives the details of the constructed apparatus and the test results. (auth)

**20064** MONTE CARLO STUDY OF NEUTRON COLLIMATION BY RECTANGULAR TUBES. Choudry, A.; Bandopadhyay, P. K. (Univ. of Rhode Island, Kingston). Nucl. Instrum. Methods, 68: 293-7(Feb. 15, 1969).

The incidence of a thermal neutron flux (e.g., from a reactor) on a collimator of arbitrary rectangular cross-section is simulated in a Monte Carlo program. The spatial and energy distribution of emerging neutrons, at any point in space is calculated to study focusing effects due to reflections from the walls. (auth)

**20065** VERSATILE EXPERIMENTAL SYSTEM FOR COINCIDENCE MEASUREMENTS INVOLVING NUCLEAR REACTIONS. Bennett, M. J.; Feldl, E.; Ellson, K.; Sheline, R. K. (Florida State Univ., Tallahassee. Los Alamos Scientific Lab., N. Mex.). Nucl. Instrum. Methods, 68: 229-34(Feb. 15, 1969).

A reaction chamber and associated experimental system are described which are intended for coincidence and correlation studies involving charged-particle-induced nuclear reactions. (auth)

**20066** IMPROVED VARIABLE WIDTH DOUBLE SLIT. Jensen, B.; Nelson, J. W. (Florida State Univ., Tallahassee). Nucl. Instrum. Methods, 68: 284-6(Feb. 15, 1969).

Improvements to a previously described variable width double slit system for beam collimation are described. (auth)

**20067** ATOMIC MASS DETERMINATIONS AT MCMASTER UNIVERSITY AND THE UNIVERSITY OF MANITOBA. PART II. A NEW SECOND-ORDER DOUBLE-FOCUSSING MASS SPECTROMETER. Barber, R. C.; Meredith, J. O.; Bishop, R. L.; Duckworth, H. E.; Kettner, M. E.; Van Rookhuyzen, P. (Univ. of Manitoba, Winnipeg). pp 717-32 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

The design and operation of a second-order double-focusing mass spectrometer is described. To test the instrument the $^{114}Cd\ ^{35}Cl - ^{112}Cd\ ^{37}Cl$ mass difference was measured. (J.W.R.)

**20068** PRESENT STATUS OF ATOMIC MASS DETERMINATIONS AT OSAKA UNIVERSITY. PART I. PRELIMINARY REPORT ON $^{40}Ca$–$^{40}Ar$ MASS DIFFERENCE DETERMINED WITH THE LARGE DISPERSION MASS SPECTROMETER. Matsuda, H.; Fukumoto, S.; Matsuo, T. (Osaka Univ.). pp 733-47 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

A high-resolution mass spectrometer was designed which has a toroidal electric field, a 1/r type magnetic field, and a homogeneous magnetic field. Preliminary measurements were made on the $^{40}Ca - ^{40}Ar$ mass difference. (J.W.R.)

**20069** PRESENT STATUS OF ATOMIC MASS DETERMINATIONS AT OSAKA UNIVERSITY. PART II. PRESENT STATUS OF THE RECONSTRUCTION OF LARGE MASS SPECTROGRAPH. Ogata, K.; Matsumoto, S.; Nakabushi, H.; Katakuse, I. (Osaka Univ.). pp 748-57 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

A large reconstructed mass spectrograph is described. A resolution problem, discovered in focusing, has since been determined to be caused by ac stray magnetic fields. (J.W.R.)

**20070** USE OF A LOCK-IN AMPLIFIER FOR MASS-DOUBLET MEASUREMENTS BY THE COINCIDENCE METHOD. Bainbridge, Kenneth T.; Dewdney, John W. (Harvard Univ., Cambridge, Mass.). pp 758-75 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

A lock-in amplifier was applied to peak-matching. Improvements were realized in sensitivity, speed of response, ability to stabilize ion beams, and reduction of the element of personal judgement associated with visual matching. (auth)

**20071** IMAGE ABERRATIONS OF MASS SPECTROMETERS INCLUDING FRINGE FIELD CALCULATIONS. Wollnik, H. (Univ., Giessen, Ger.). pp 779-92 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

Good mass spectrographs that are required to have a high resolution and a high luminosity, i.e., entrance slit area times accepted solid angle, must be at least partially free of image aberrations. Their correction has been tried always assuming the deflecting field to rise and fall off at the field boundaries as step functions. Recently the ion trajectories also in realistic fringe fields have been calculated. Corresponding calculations of image aberrations are described here briefly. Further it is shown how such aberrations can be calculated numerically without too much effort and how they can be corrected. (auth)

**20072** FIRST RESULTS WITH THE PRINCETON RF SPECTROMETER. Smith, Lincoln G. (Palmer Physical Lab., Princeton, N. J.). pp 811-30 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

The design and operation of the Princeton rf mass spectrometer is described. Preliminary measurements on the $N_2^+ - CO^+$ doublet are reported. (J.W.R.)

**20073** METHOD OF MAKING CATHODES BY NEUTRON BOMBARDMENT. Denison, James W. Jr. (to Trak Microwave Corp.). U. S. Patent 3,425,112. Feb. 4, 1969. Filed Oct. 8, 1964.

A method is disclosed for producing improved electron emissive cathodes for vacuum tubes and other electronic applications. The method employs nuclide reactions through neutron bombardment to transmute atoms of rare earth metals within a host metal base into a pure metal matrix of low work function, without the presence of oxygen. The irradiated base and matrix is then heated in a vacuum to cause the rare metal atoms within the matrix to migrate to the host surface where they form a monatomic layer of the low work function pure metal. The method is applicable to a variety of base metals and rare earths transmutable into pure metals having the desired work function characteristics. A detailed process is disclosed as a preferred embodiment using nickel as the host metal and lanthanum as a dopant which is transmuted into barium atoms in a matrix within the nickel. (Offic. Gaz.)

## Radiation Effects on Instruments and Instrument Components

*Refer also to abstract 20987.*

**20074** (IAE-1658) RADIOINDUCED DISLOCATIONS IN GERMANIUM TUNNEL DIODES. Litvinov, V. L.; Ukhin, N. A. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Moscow. Institut Atomnoi Energii). 1968. 20p. (In Russian). Dep.

Descriptions are given of radiation-induced changes in electric characteristics of germanium tunnel diodes irradiated with electrons and neutrons. (R.V.J.)

**20075** (N-68-37035) PULSES GENERATED BY IONIZING RADIATION IN PHOTOMULTIPLIER TUBES. Macar, P.; Macau, J. P. (Liege Univ. (Belgium). Institut d'Astrophysique). Jan. 1968. 28p. (ESRO-SM-72). CFSTI.

The utilization of photomultiplier tubes in pulse-counting systems in nuclear physics as well as in satellites makes necessary the study of their behavior in the presence of ionizing particles. It seems in fact that, when these tubes are subject to bombardment by such particles, the output signal changes on a wide scale. A theoretical study of phenomena liable to change the output of the photomultiplier is given. Some ASCOP tubes (types 542F and 542G) were subjected to $\alpha$, $\beta$, and $\gamma$ radiation. The results confirmed the previsions, i.e. that, for a given energy, tubes are more sensitive to $\alpha$ and $\beta$ particles than to $\gamma$-rays. Moreover, considering their sensitivity to radiation, the utilization of tubes with sapphire window is to be excluded. (auth) (STAR)

**20076** DOSE RESPONSE OF SOME SEMICONDUCTOR SOLAR CELLS IN HIGH-FLUX GAMMA FIELDS. Trofimov, V. M.; Vasil'ev, A. G. At. Energ. (USSR), 26: 77-8(Jan. 1969). (In Russian).

Dosimetric responses of solar cells PESS-U2 (sulfur silver), photodiodes PD-1 (germanium) and PDS-1v (silicon) in cobalt installations $P_\gamma$ = 10 to 900 R/sec at air temperatures from 25 to 45°C were studied. The detectors were placed in light-isolated shells in a $\gamma$-field in which the doses were measured by ferrosulfate dosimeters with the order of error not exceeding 2%. Tabulated data revealed that the best responses were found in small dimension, portable, PD-1 diodes which, after preliminary irradiation with 100 mR, exhibited strong radioresistance and high sensitivity for measuring $\gamma$ doses from 10 R/sec. The varying sensitivity of the examined solar-cells indicates the necessity of their preliminary calibration in $\gamma$ fields. (R.V.J.)

# LIFE SCIENCES

## Biochemistry, Physiology, and Molecular Biology

*Refer also to abstracts 19947, 19952, 20147, 20148, 20216, 20226, 20261, 20297, 20353, 20360, 20365, 20372, 20383, 20388, 20389, 20402, 20424, and 20439.*

**20077** (AD-673381) RELATION BETWEEN Ca AND Sr TRANSPORT RATES, AS DETERMINED SIMULTANEOUSLY IN ISOLATED SEGMENTS OF VETCH, BARLEY, AND PINE ROOTS. Hutchin, Maxine E.; Vaughan, Burton E. (Naval Radiological Defense Labs., San Francisco, Calif.). Apr. 1968. 28p. (USNRDL-TR-68-66). CFSTI.

Root segments of vetch, barley, and pine were exposed to nutrient containing $^{85}Sr$ and $^{45}Ca$ tracers. Transport in both vetch and barley usually declined before an elapsed time of 24 hours unlike corn, which maintained its steady state beyond 24 hours. Pine was radically different in that it showed no difference between acropetal and basipetal transport rates and had very low rates. Sr transport in all plants studied to date followed that of Ca and the ratio of Sr/Ca transported was equal to the ratio of Sr/Ca in the nutrient. In vetch, stable Ca transport was reduced to one-fifth when Sr concentration was increased from 0.5 mM to 2.5 mM. Yet stable Sr transport did not change, indicating that the effect on transport was not due to competitive inhibition. A similar effect was less pronounced in barley, but could not be detected in pine. The magnitude of the transport rates varied considerably between the various species, corn being greatest followed by barley, vetch, and pine in decreasing order. Transport did not correlate with root weight or surface area; it amounted to from 0.03 to 0.60 nanomoles per hour in these experiments as compared to 7 nanomoles per hour previously established in corn (in all cases, 55 mm segments, sectioned 10 mm from apex). (auth)

**20078** (AD-673529) EFFECT OF IONIZING RADIATIONS ON TOTAL PROTEIN-BOUND NEUTRAL HEXOSES IN THE PLASMA OF MICE. Evans, A. S.; Quinn, F. A.; Brown, J. A.; Strike, T. A. (Armed Forces Radiobiology Research Inst., Bethesda, Md.). Mar. 1968. 23p. (AFRRI-SR-68-4). CFSTI.

Total protein-bound carbohydrates (PBC), as neutral hexoses, were quantified in the plasma of C3H mice as a function of time relative to whole-body exposure to either monoenergetic 14 MeV neutrons or mixed $\gamma$-neutron radiations delivered at a rate of approximately 20 Rads/min. The reported doses, 365 to 530 Rads, were those which yielded survivors under the stress of daily bleeding. A striking difference was observed between those radiosensitive animals that died after exposure and the more resistant individuals that, although exposed to identical doses, survived the observation period. In the former population, the PBC concentration rose to high values and remained elevated until the death of the animal. By contrast, the survivors showed little change in PBC, deviating only slightly from their preirradiation base line values. The mean preirradiation PBC concentration in the mice which survived 30 days, while statistically significant ($p < 0.01$) only at the lowest reported dose, was consistently lower than that of those which died during the same period. The magnitude of the difference was inversely related to the radiation dose. The refinement of these data to provide an index to radiosensitivity prior to and prognosis after irradiation in otherwise healthy individuals is proposed. (auth)

**20079** (BNL-50058, pp 1-16) STEPS IN THE REPAIR OF DNA: FACT AND FANCY. Setlow, R. B. (Oak Ridge National Lab., Tenn.).

Reparable radiation damage is discussed with reference to a particular photochemical change in DNA, i.e., the cyclobutane-type dimers between adjacent pyrimidine residues in polynucleotides. How cells react to uv irradiation in terms of DNA synthesis, removal of lesions from DNA (excision), repair replication and rejoining of broken DNA strands in vivo, and two models explaining the possible steps in excision are included in the discussion. (C.O.)

**20080** (CERN-69-1) ESTIMATION OF THE DISTRIBUTION OF ENERGY LOSS OF IONIZING RADIATION FROM OBSERVATIONS OF THE INITIAL RECOMBINATION OF THE IONS IN A GAS. Sullivan, A. H. (European Organization for Nuclear Research, Geneva (Switzerland)). Jan. 28, 1969. 90p. Dep.

Thesis. Submitted to Univ. of London, Eng.

The importance of ionization density in radiobiological processes, and the concepts involved, are briefly reviewed. Initial recombination theory is developed to a stage where it can be used to estimate the distribution of energy absorbed as a function of the size of ionization events from observations of the dependence of the collected ion current on applied electric field and gas pressure in a suitable ionization chamber. An ionization event is defined from the theory and is the ionization produced over a distance equivalent to about 700 Å in tissue. The experimental and theoretical problems involved are investigated in detail and it is shown that the method can only have a rather poor resolution and reproducibility. Distributions are experimentally determined for $^{60}Co$, $^{137}Cs$, and $^{226}Ra$ gamma rays, PuBe, 3-MeV, 15-MeV, and fission neutrons and for alpha particles from plutonium. These distributions are compared, where possible, with calculated distributions and it is shown that the discrepancies are within what is expected from the method. An attempt is made to use the distributions obtained to analyze a set of radiobiological data, where it is suggested that the analysis is limited more by the fact that 700 Å is not a biologically appropriate distance for the averaging of energy loss than by the limited precision of the measured distributions. (auth)

**20081** (MIT-952-5(Pt.1)) RADIUM AND MESOTHORIUM POISONING AND DOSIMETRY AND INSTRUMENTATION TECHNIQUES IN APPLIED RADIOACTIVITY. Annual Progress Report. Evans, Robley D.; Kolenkow, Robert J. (Massachusetts Inst. of Tech., Cambridge. Dept. of Physics). May 1968. Contract AT(30-1)-952. 540p. Dep. CFSTI.

Separate abstracts were prepared for the five sections of the report. (D.C.W.)

*For abstracts of individual sections see: 20215-20217, 20402, and 21331.*

**20082** (NRC-TT-1345) SHORT NOTE ON THE DISTRIBUTION AND BIOLOGICAL ACTION OF RADIOACTIVE ISOTOPES. Granone, F. G. Translated by D. A. Sinclair (National Research Council of Canada, Ottawa), from Minerva Radiol., Fisioter. Radiobiol., 11: 604-8(1966). 10p. Dep.

A review of the literature on biological effects and distribution of radioisotopes in various tissues of the animal body is presented. It is pointed out that data on the distribution of radioisotopes are of great importance not only for the analysis of the specific character of the biological action in relation to the path of entry into the organism, but also for the estimation of dose levels in the organs and tissues. The factors determining the effectiveness of $\alpha$, $\beta$, and $\gamma$ emitters are discussed. Manifestations of radiation sickness resulting from deposition of radioisotopes in bone, liver, and other tissues are described. The complex character of the dose-effect curve is discussed. (H.L.W.)

**20083** (ORNL-TM-2466, pp 18-39) UPTAKE AND EXCRETION OF $^{134}Cs$ FROM FALLOUT SIMULANT AND VEGETATION BY COTTON RATS. Kitchings III, J. T.; Dunaway, P. B.; Story, J. D.; Tucker, L. E. (Oak Ridge National Lab., Tenn.).

Cesium-134 tagged simulants with varying in vitro nuclide solubilities were analyzed with respect to absorbabilities of the $^{134}Cs$ by the gastrointestinal tracts of cotton rats (Sigmodon hispidus). Whole-body retentions and excretory patterns were used to discern variations in $^{134}Cs$ metabolism caused by solubility differences. Transit times of the simulant particles through the GI tract were determined, because the particles constitute internal point sources as long as they are present. A mass-loading gavaging technique was developed to insert the simulant into the stomachs of the rats. Three different simulants were used, with injected dose and in vitro solubilities as follows: 0.197 $\mu$Ci, 60.6%; 0.201 $\mu$Ci, 17.6%; 0.209 $\mu$Ci, 4.3%. Whole body, fecal, and urine samples were counted every 18 and 24 hr for 66 hr and then every 24 hr until 158 hr postinjection. Analysis of fecal material showed a rapid increase in radioactivity until the 42nd hr postadministration. Complete passage of the particulate matter was assumed to have occurred by the 66th hr. Regression analysis, using the percent activity remaining after 66 hrs gave Y-intercepts of 68.7%, 16.8%, and 8.2%. The elimination coefficients ($\lambda_b$) and biological half-lives ($T_b$) for the respective three groups of experimental animals were: 0.76%/hr, 3.79 days; 1.16%/hr, 2.50 days; 1.46%/hr, 1.98 days. The second experimental phase was to establish uptake rates and equilibrium levels for $^{134}Cs$ in lab-born and wild-trapped cotton rats under chronic ingestion conditions and to determine retention curves for $^{134}Cs$ following termination of the chronic ingestion. Lettuce tagged with $^{134}Cs$ was given daily in doses of 0.06 $\mu$Ci to groups of laboratory-born and wild-trapped cotton rats for approximately 30 days. Whole body and excreta counts were made at various

intervals over a 712-hr time span. After 712 hr, administration of the isotope was stopped and measurements of excretion of cesium were begun. Serial sacrifices were made during both the accumulation phase and excretion phase of the equipment, and eight tissues were analyzed for $^{134}Cs$. Accumulation and loss of $^{134}Cs$ was slowest in muscle. It appeared that the type of ingestion, acute (simulant) vs chronic (vegetation), influenced the metabolic kinetics of $^{134}Cs$ in cotton rats under laboratory conditions. Presumably, the cesium $T_b$ was shorter in animals receiving a single dose of simulant because less simulant is incorporated in compartments with slow uptake and long retention times. (auth) (TSS)

**20084** URACIL PHOTOPRODUCTS FROM URACIL IRRADIATED IN ICE. Khattak, M. N.; Wang, S. Y. (Johns Hopkins Univ., Baltimore). Science, 163: 1341-2(Mar. 21, 1969).

Two new products were isolated from uracil irradiated with uv light in frozen aqueous solution. As judged by mass, nuclear magnetic resonance, and uv and infrared spectra, one is a photopolymer, $U_2$, and the structure of the other is probably 6-4′-[pyrimidin-2′-one]-uracil. Formations of these products between bases are apparently common photoreactions, and may be important to the study of the photochemistry and photobiology of nucleic acids. (auth)

**20085** EFFECT OF PHOSPHORUS AND ZINC LEVELS IN THE SUBSTRATE ON $^{65}Zn$ DISTRIBUTION IN SUBTERRANEAN CLOVER AND FLAX. Millikan, C. R.; Hanger, B. C.; Bjarnason, E. N. (Victorian Plant Research Inst., Burnley Gardens, Australia). Aust. J. Biol. Sci., 21: 619-40(Aug. 1968).

Subterranean clover (Trifolium subterraneum) and flax (Linum usitatissimum) were grown in water cultures containing $^{65}Zn$ and all combinations of deficient or normal Zn supply and low or excess phosphate levels. The $^{65}Zn$ distribution in the plants was determined by autoradiographs and radioassays. Irrespective of P or Zn level in the substrate, the overall trend was a fall in $^{65}Zn$ concentration with time in all aerial tissues of both species. However, the variation in $^{65}Zn$ concentration with Zn-deficient plants showed considerable relative differences from that within plants with a normal Zn supply, both between comparable tissues, and with time. In Zn-deficient subterranean clover a greater percentage than normal of the total Zn in the plant was located in the roots. With flax the $^{65}Zn$ concentrations in leaves and stems varied independently with time. In this species $^{65}Zn$ accumulated in the nodes and as islands of high concentration in the oldest leaves. Within Zn-deficient plants of both species, $^{65}Zn$ concentrations were highest in tissues actually involved in Zn-deficiency symptoms, i.e., little leaves of subterranean clover, or the apical tissues of flax affected with dieback. There was considerable retranslocation of $^{65}Zn$ from the oldest leaves of Zn-deficient subterranean clover. Increase in phosphate supply caused increased $^{65}Zn$ concentrations in the oldest leaves of subterranean clover at deficient Zn levels, and also had differential effects on the relative distribution of $^{65}Zn$ within lamina and petiole depending on the level of Zn supply. Plants showing little leaf symptoms had P/Zn ratios greater than 400 in their tops. Difference in phosphate supply had no significant effect on $^{65}Zn$ distribution in flax. (BBB)

**20086** $^{45}Ca$ UPTAKE AND TISSUE Ca OF GUINEA PIG TAENIA COLI IN ISOTONIC HIGH-K/Na-DEFICIENT MEDIUM. Urakawa, Norimoto; Karaki, Hideaki; Ikeda, Miyoshi (Tokyo Univ.). Jap. J. Pharmacol., 18: 294-8(Sept. 1968).

The $^{45}Ca$ uptake and tissue Ca content of guinea pig taenia coli during K-induced contracture were examined. In hypertonic 40 mM (hyper-40) K medium (149.1 mM Na) large tonic tension averaging 12 g was induced in the muscle and both $^{45}Ca$ uptake and tissue Ca of the muscle increased, while in isotonic 152 mM (iso-152) K medium (0 mM Na) only a small tension remained and $^{45}Ca$ uptake did not increase and tissue Ca decreased. A possible mechanism and cause of this difference are discussed. The cause of the difference in $^{45}Ca$ uptake and tissue Ca in hyper-40 K and iso-152 K media may be the different composition in the external medium. (BBB)

**20087** EFFECT OF TOTAL-BODY X IRRADIATION ON THE PROPERTIES OF POLYRIBOSOMES IN NORMAL RAT LIVER. Baeyens, W.; Goutier, R. (CEN, Mol, Belg.). Arch. Int. Physiol. Biochim., 76: 785-96(Sept. 1968).

The well-known inhibition of DNA synthesis by x irradiation in regenerating liver may be ascribed to impaired synthesis of the enzymes involved in DNA synthesis. X irradiation also interferes with the synthesis of nuclear, rapidly labeled RNA in regenerating liver. The inhibition of protein synthesis, indicated by the decreased formation of enzymes, therefore arises at least partly from an interference by irradiation with the transcription process. To determine whether any alteration in the translation phase also occurs after irradiation, a study was made of one factor involved in the translation: the properties of polysomes in livers of normal and irradiated rats, since polysomes play an important role in protein synthesis. Polysomes were prepared from normal rat liver, 24 hr after total-body x irradiation with doses ranging from 1000 to 6000 R. Sucrose density gradient analysis of the polysomes revealed a marked increase, in comparison with the nonirradiated controls, of the proportion of higher polysomes in the irradiated groups. Electron microscopic examination of the polysome preparation indicated the presence, in the irradiated group, of a membranous component, the significance of which is discussed. The observed shift in polysome distribution is ascribed to the interference of x irradiation with the synthesis of m-RNA. (BBB)

**20088** THERMAL AND 2450 MHz MICROWAVE ENERGY EFFECT ON THE DESTRUCTION OF THIAMINE. Goldblith, Samuel A.; Tannenbaum, Steven R.; Wang, Daniel I. C. (Massachusetts Inst. of Tech., Cambridge). Food Technol., 22: 64-6 (Oct. 1968).

This study compared the effects of thermal energy and microwave energy at 2450 MHz on the destruction of thiamine in buffer solution, to ascertain whether there are effects of microwaves on the destruction of thiamine (vitamin $B_1$) other than those due to heat alone. Solutions of 250 μg/ml of thiamine in pH 6.8 phosphate buffer were used. Conventional heating experiments of thiamine were conducted at 101.5 and 108.5°C for 50 and 25 min respectively. Microwave heating of thiamine was conducted at 102.8°, 33°, and 0°C for 50, 30, and 45 min respectively. The results showed that the degree of destruction of thiamine by microwave energy at 102.8°C was due solely to the temperature. Exposing thiamine solution at 0°C for 45 min and 33°C for 30 min to microwaves showed no destruction. It is concluded that microwave energy per se has no effect on the destruction of thiamine. (BBB)

**20089** STUDIES OF BLOOD GOLD LEVELS IN PATIENTS WITH JAUNDICE USING NEUTRON ACTIVATION ANALYSIS. Botzvadze, E. Sh.; Mosulishvili, L. M.; Kuchava, N. E.; Ghinturi, E. N. (Tbilisi Medical Inst., USSR. Inst. of Physics, Tbilisi, USSR). Phys. Med. Biol., 14: 19-26(Jan. 1969).

A method for neutron activation analysis of gold in blood is described, and the results of the measurement of blood gold levels in various forms of liver disease are given. Blood gold levels fall in hepatic disease and the level reached is lower in the more severe forms and in those involving general hepatocellular damage. High concentrations of gold were found in the livers of two patients who died from acute hepatic necrosis. The behaviour of gold is rather similar to that of other elements in the blood and in particular to that of iron and zinc. It is suggested that these results indicate that gold plays some physiological role. (auth) (UK)

**20090** DAY-TO-DAY VARIATION OF DIETARY INTAKE AND URINARY EXCRETION OF FALLOUT $^{137}Cs$ AND STABLE K IN MAN. Fujita, M.; Iwamoto, J.; Kondo, M.; Yabe, A. (Japan Atomic Energy Research Inst., Tokai). Health Phys., 16: 185-95(Feb. 1969).

The daily dietary intake and daily urinary excretion of fallout $^{137}Cs$ and stable K were determined for several volunteers for about 90 days during the period December 1964 to March 1967. The subjects ate identical diets during the experimental period, which consisted of 90 days in all, although these were not consecutive. The total experimental period was divided into four groups, and the data of each group received separate statistical analysis. The coefficient of variation (S.D./Mean Value) for the daily dietary intake of $^{137}Cs$ varied among the four groups from 11 to 23%, whereas that of K was always about 15%. The same coefficient of variation of the daily urinary excretion of $^{137}Cs$ varied from 11 to 36%, with a mean value of 20%, while for urinary K it ranged from 17 to 37%, with a mean of 24%. The correlations of $^{137}Cs$ with K in the urine were different for different individuals, and the values of the correlation coefficients were, in general, not high. Relationships between the intake and urinary excretion of the two nuclides were discussed. The fraction in urine to that in total excreta was also given. (UK)

**20091** THYROID FUNCTION DURING POSTNATAL DEVELOPMENT IN THE RAT. Samel, Milan (School of Medicine, Martin, Czech.). Gen. Comp. Endocrinol., 10: 229-34(Apr. 1968).

Radioiodine uptake, thyroid weight, and serum thyroxine concentrations were studied in rats after birth. Radioiodine uptake, expressed as the percentage of the injected dose per mg of thyroid weight, showed higher values in newborn rats than during the next two weeks of life. A second increase in values takes place during the third and fourth week and is followed by a decline to the adult values. Serum thyroxine

concentration rose sharply within the first two days after birth, followed by a sharp decline. A second peak is observed at the beginning of the third week. Thyroid $^{131}I$ uptake during the first 2 weeks depends on environmental temperature. The values are significantly higher at nest temperature (35°C) than at room temperature (24°C). A compensatory increase of $^{131}I$ uptake in the thyroid remnant may be observed as early as two days after partial thyroidectomy performed during the first postnatal week. Administration of thyroxine inhibits $^{131}I$ uptake in normal young rats as well as the compensatory changes in hemithyroidectomized rats. (BBB)

**20092** THE EFFECT OF BLOCKADE OF THE ARTERIAE CILIARES POSTERIORES LONGAE ON THE TRANSPARENCY AND ON THE TRANSPORT OF $^{45}Ca$ INTO THE RABBIT'S CORNEA. Votockova, J. (Charles Univ., Prague); Praus, R.; Sulcova, H.; Brettschneider, I.; Sidak, Z. Arch. Klin. Exp. Ophthalmol., 176: 148-54(Oct. 4, 1968).

Radioactivity of the cornea was determined 30 min after intravenous injection of rabbits with 0.1 mCi/Kg (body wt) of $^{45}Ca$ (as $CaCl_2$) at various intervals after severing the long posterior ciliary arteries. In 120 rabbits both arteries were cut through the sclera on the right eye at a distance of 3 to 4 mm from the limbus. The left unoperated eye served as a control. The rabbits, divided into 12 groups, were observed for 30 min, 3 hr, 5 hr, 1 day, 2 days, 3 days, 1 week, 2 weeks, 3 weeks, 1 month, 2 months, and 3 months. In 106 rabbits the cornea remained clear. It was found that the transport of $^{45}Ca$, given intravenously, into the cornea was not limited by the blockade of these arteries. (BBB)

**20093** ULTRAVIOLET RADIATION AND THE ORIGIN OF LIFE. Ponnamperuma, Cyril (Ames Research Center, Moffett Field, Calif.). Contract AT(11-1)-875. Photophysiology: Current Topics, 3: 253-67(1968).

The role of uv radiation in the formation of organic molecules in the primitive atmosphere of the earth is reviewed, and several experiments in which uv light was used as a source of energy for irradiation of a model primitive atmosphere are reported. One flask contained methane, ammonia, and water and a lower flask represented the ocean. A window on the upper flask passed uv light. To excite the methane, wavelengths below 1500 Å were required. A light source consisting of a 1-atm He lamp provided a continuous spectrum from 1000 to 2000 Å. The total amount of energy was calculated to be $10^{10}$ photons $cm^{-2}$ $sec^{-1}$, or ~5 orders of magnitude less than the estimated solar flux. At the end of a 48-hr experiment, less than half a percent of methane was converted to organic compounds. Hydrogen cyanide is considered to be one of the main products when the primitive atmosphere of the earth is exposed to any form of energy. When hydrogen cyanide in dilute solution containing about $10^{-3}$ mole/l was exposed to uv light and the products examined, a large number of discrete organic molecules were formed, including about 10% of the reaction products as urea, 1% adenine, and ½% of guanine. Aminomalononitrile is an important intermediate in the synthesis of adenine. The monoaminomalononitrile is transformed into 4-aminoimidazole 5-carbonitrile either by direct reaction with formamidine or by the rearrangement of hydrogen cyanide by the rearrangement of hydrogen cyanide tetramer. The carbonitrile, by hydrolysis gives the carboxamide, which in turn, can condense with hydrogen cyanide to give adenine. It can also condense with cyanogen to give guanine. The purine hypoxanthine and diaminopurine can also be formed via the tetramer. Hydrogen cyanide is, therefore, an important biochemical in primitive earth studies. On account of the wide distribution of cyanide in the universe, similar reactions may have occurred elsewhere in the solar system. Formaldehyde is a product of the irradiation or the action of electric discharge on the earth's primitive atmosphere. When formaldehyde was exposed to uv light, a series of sugars was formed, including ribose and deoxyribose. The conversion by uv irradiation of adenine to adenosine, adenosine to adenosine monophosphate, monophosphate to diphosphate, and the diphosphate to triphosphate has been established. When an aqueous solution of glycine and leucine was exposed to uv light in the presence of cyanamide, the dipeptides glycyl-glycine, glycyl-leucine, leucyl-glycine, and leucyl-leucine, and some tripeptides were formed. These results showed that under simulated primitive earth conditions molecules of biological significance could be synthesized by the action of uv radiation. (BBB) (TSS)

**20094** CELL POPULATION ANALYSIS OF RADIATION LEUKEMOGENESIS IN MICE. Sato, Chikako (Tohoku Univ., Sendai). Tohoku J. Exp. Med., 96: 97-109(Sept. 1968).

Young C57Bl mice were x irradiated with a leukemogenic dose in four fractions with an interval of 7 days. Differential cell count was carried out in the course of tumor development on the cellular suspension of the thymus or lymph nodes. Normal differentiation of large lymphocytes to small lymphocytes was always seen after each irradiation. The accumulation of blast cells owing to maturation arrest was not seen in the whole period of regeneration. The population of neoplastic cells appeared among normal lymphocytes as early as 14 days after the fourth irradiation. The rate of tumor cell induction at the time of irradiation was $1 \times 10^{-4}$ to $1 \times 10^{-5}$/R in the blast cells. The population of self-replicating cells increased exponentially with the doubling time of 7.3 days and constituted a large thymoma. In the lymph nodes, numerous foci of unusual proliferation of blast cells without differentiation were observed in the cortex, but further development of the foci was suppressed. The immunological insufficiency in the thymus may be responsible for the development of neoplastic cells in the organ. Extreme lymphopenia for a long period may also be associated with tumor cell development. (BBB)

**20095** PRIOR X IRRADIATION AND THE CELLULAR RESPONSE TO NERVE CRUSH: DURATION OF EFFECT. Cavanagh, J. B. (Inst. of Neurology, London). Exp. Neurol., 22: 253-8(Oct. 1968).

Nuclear populations were studied in rat sciatic nerves 14 days after nerve crush in normal animals and at various periods after 1000 R of x irradiation. The mean nuclear population of normal rat sciatic nerves was found to be 247.4 cells per unit volume of nerve. Fourteen days after nerve crush this increased in unirradiated animals to 1375.6 after irradiation. Three weeks before nerve crush the mean population 14 days later fell to 700.6, which is 50.4% of the unirradiated population. With irradiation 3 months before nerve crush, the mean population 14 days later was 630.4, or 45.3% of the unirradiated control figure. When irradiation was done six months before nerve crush, the mean figure was 784.1, or 56.4% of controls and not significantly different from the nerves crushed within 3 weeks of irradiation. For the group irradiated 9 months before nerve crush the mean nuclear population 14 days after crushing was 739.2 or 53.1% of controls and not significantly different from nerve crushed with three weeks of irradiation. When compared in nerves crushed within three weeks of irradiation, there were no detectable differences in the cellular changes, whether the animals were kept for 3, 6, or 9 months before crushing. The chief feature was the gross nuclear aberrations produced, particularly in neurilemma cells. It was concluded that the capacity of cells in peripheral nerve to proliferate in response to nerve crush is seriously impaired if the limb has been previously x irradiated with 1000 rad. There was no difference in this effect whether the irradiation was done 3 weeks or 9 months before nerve crush. (BBB)

**20096** ON THE CONTENT OF SERUM ENZYMES LDH, GOT, AND GPT IN CANCER AND THE POSSIBILITY OF DIAGNOSTIC AND PROGNOSTIC INFERENCES. Buchelt, Longin; Hess, Freidhelm (Philipps-Univ., Marburg, Ger.). Strahlentherapie, 136: 574-80(Nov. 1968). (In German).

In 523 patients the evolution of the enzymes LDH, GOT, and GPT was followed. The percentage of pathological values was remarkably low in all groups and concerned, at the most, only one third of the patients. The influence of radiotherapy was studied in patients with bronchial carcinoma, permitting a tumoral response study and in (postoperative) mammary carcinoma for a study of general tissue reaction. In bronchial carcinoma a significant elevation of the serum enzyme values was observed when a dose of 2000 to 3000 R had been administered. In mammary carcinoma the variations of the enzyme values were not as characteristic for an expected tissue lesion. Some cases were followed up for more than five years and it was observed that enzyme elevation occurred in patients with local recurrences and metastases in contrast to patients without clinical symptoms. (auth)

**20097** ENHANCEMENT OF RADIATION EFFECTS BY PHOSPHATE BUFFER AT 77°K. Taylor, William D.; Snipes, Wallace (Pennsylvania State Univ., University Park). Int. J. Radiat. Biol., 14: 277-80(1968).

Nitrogenated aqueous phosphate buffer solutions containing dihydrouracil were frozen at 77°K and irradiated with 77 kR of cobalt-60 γ rays. The uracil produced was assayed spectrophotometrically. The experiments were also performed at room temperature and the results of varying the phosphate and dihydrouracil concentrations were presented. It was concluded that the enhancement of radiation action in frozen aqueous buffer solutions probably arose from the direct production of a phosphate radical which subsequently reacted with biological molecules. (F.M.M.)

**20098** CHANGE IN ACTIVITY OF ASPARTATE-AMINOTRANSPHERASE IN BRAIN SUBCELLULAR FRACTIONS UNDER EFFECT OF IONIZING RADIATION AGAINST THE BACKGROUND OF EXCLUSION OF CORTIADRENAL FUNCTIONS. Cherkasova, L. S.; Pikulev, A. T.; Konyaeva, M. P.; Tkach, V. M. (Labor Red

Banner State Univ., Minsk). Ukr. Biokhim. Zh., 40: 514-18(1968). (In Russian).

The activity of aspartate-aminotransferase of brain subcellular fractions in albino rats irradiated with relatively small doses of interstitial energy neutrons and x rays was studied as dependent on the initial content of corticosteroids in an organism. (auth)

**20099** ELECTRON MICROSCOPIC EXAMINATION OF DIFFUSION AND ABSORPTION OF THORIUM DIOXIDE IN THE COCHLEA OF THE GUINEA PIG. 3. LIMBUS SPIRALIS. Ilberg, Ch. v. (Univ., Frankfurt am Main). Arch. Klin. Exp. Ohren-, Nasen- Kehlkopfheilk., 192: 163-75(Oct. 24, 1968). (In German).

In a study of the structure of the limbus spiralis by electron-microscopy, injection of $ThO_2$ into the perilymph and the endolymph revealed that the limbus spiralis consists of sponge-like connective tissue. Its mesh-work (comparable with the spiral ligament) is connected with the scala tympani as well as with the scala vestibuli. The stroma cells of the connective tissue are shown to take up the $ThO_2$ by pinocytosis from the surrounding perilymphatic spaces. The spaces of the connective tissue described are closed against the scala media by the epithelial cells of the sulcus internus and the interdental cells. There is no free diffusion through their intercellular spaces. The interdental cells take up the injected $ThO_2$ at their perilymphatic surface and expell it into the endolymphatic space above them. Functional aspects of this observation are discussed. (BBB)

**20100** UPTAKE AND RETENTION EXPERIMENTS OF RADIORUTHENIUM IN MAN. I. Yamagata, N. (Inst. of Public Health, Tokyo); Iwashima, K.; Iinuma, T. A.; Watari, K.; Nagai, T. Health Phys., 16: 159-66(Feb. 1969).

In connection with the pre-operational research program for the establishment of the first fuel reprocessing plant in Japan, the metabolism of ruthenium in man was studied in experiments involving the oral administration of metabolized tracer in shellfish. A whole body counter-scanner tracer in vivo the movement of ingested tracer from stomach to rectum within 24 hr. Whole body retention was best fitted by a three-component exponential function with time, the fastest component being caused by a large fecal excretion which amounted to about 95% of administered dose within two days. The second component could be attributed to the prolonged retention of radioruthenium inside the gastrointestinal tract, the biological half-life being 2.3 days. The slowest component, about 1% of the administered dose, was retained in the body with a half-life of 30 days, and this fraction was considered to be absorbed from the gastrointestinal tract. Experiments with non-metabolized tracer in the chemical forms of the chloro-complexes of nitrosylruthenium(III) and ruthenium(III and IV) resulted in a higher gastrointestinal absorption of the former by a factor of about three. It was suggested that changes in the chemical and physical states of ruthenium, of pH and of different periods of time following preparation until administration, as well as changes in residence time in the gastrointestinal tract, might cause variability in absorption. (UK)

**20101** RETENTION OF $^{134}Cs$ AS AN INDEX TO METABOLISM IN THE COTTON RAT (SIGMODON HISPIDUS). Baker, Charles E.; Dunaway, Paul B. (Oak Ridge National Lab., Tenn.). Health Phys., 16: 227-30(Feb. 1969).

Biological half-lives ($T_b$) of $^{134}Cs$ were compared with resting metabolism measurements in cotton rats maintained at 5, 15, and 25°C in an endeavor to develop a technique for determining respiration rates of animals in the field. Average $T_b$ values of the experimental groups were 6.3 days at 5°, 6.9 days at 15°, and 8.1 days at 25°; oxygen consumption measurements (cc/hr/g) averaged 3.2, 2.3, and 1.5, respectively. Regression and correlation analysis performed on the data of the individual animals revealed a strong linear relationship between $T_b$ of $^{134}Cs$ and resting metabolism. Although $^{134}Cs$ retention correlated well with oxygen consumption, it could not be shown to correlate with body weight. Further investigations of 24-hr oxygen consumption measurements made over a wider range of metabolic rates (i.e., both above and below thermoneutrality) and consideration of certain factors which promote elimination of cesium were necessary to validate the apparent relationship between $^{134}Cs$ retention and general metabolism. (UK)

**20102** RETRANSLOCATION OF $^{86}Rb$, $^{137}Cs$, AND K TO NEW LEAF GROWTH IN BUSH BEANS. Wallace, Arthur (Univ. of California, Los Angeles). Plant Soil, 29: 184-8(Aug. 1968).

The validity of using radionuclides of Rb and Cs as tracers for K was studied by determining whether $^{86}Rb$ and $^{137}Cs$ are as readily translocated from old to new growth in bush bean, Phaseolus vulgaris, as is K. Bean plants were exposed to either $^{86}Rb$ to $^{137}Cs$ with and without carrier Rb and Cs for 48 hr in a complete nutrient solution. These solutions were then discarded, and the plants were then allowed to grow for 11 additional days in complete nutrient solution except that K was omitted. Measurement of $^{86}Rb$, $^{137}Cs$, and K in new leaves indicated that $^{137}Cs$ was retranslocated to the new growth much slower than was K but that proportionately more $^{86}Rb$ was in new leaves than K, and these results were independent of the presence or absence of the respective carriers. Considerably more $^{86}Rb$ than $^{137}Cs$ was absorbed by the plants either with or without the carriers. (BBB)

**20103** METABOLISM AND TOXICITY OF THERAPEUTIC CHELATING AGENTS. PART 4. EXCRETION AND METABOLIC DEGRADATION OF EDTA AND DTPA. Havlicek, Frantisek; Bohne, Felicitas; Zorn, Herbert (Kernforschungszentrum, Karlsruhe, Ger.). Strahlentherapie, 136: 604-8(Nov. 1968). (In German).

The excretion of $^{14}C$-labeled EDTA and DTPA was studied in rats. Within 24 hours 95% of the radioactivity was excreted in the urine, 0.5% in the feces, and 0.7 to 1.3% with the expired $CO_2$. From the experiments a metabolic degradation of the chelates could be deduced which concerned mainly the acetate groupings. The decay did not depend on the chelated metal or on the dose of the chelate but only on the ligand. It seemed likely that the metabolic decay took place in the kidneys. (auth)

**20104** HISTOCHEMICAL DETERMINATIONS OF ISOCITRATE-, SUCCINATE-, AND MALATE-DEHYDROGENASE AS WELL AS CYTOCHROME OXIDASE IN RAT ORGANS FOLLOWING WHOLE-BODY IRRADIATION. Walther, Gotfried; Schmidt, Karl-Juergen; Ladner, Hans-Adolf (Johannes-Gutenberg-Univ., Mainz). Strahlentherapie, 136: 500-7(Oct. 1968). (In German).

The histochemical determination of Isocitrate-, Succinate-, and Malate-dehydrogenase as well as cytochrome oxidase in small intestine, pancreas, spleen, ovary, and adrenals was done in 12 Wistar rats each, which were total body irradiated with 650 R and 1950 R and killed at different times (24, 48, and 72 hours) after irradiation. The results were compared with those obtained in 10 control animals. The differences in activity found after irradiation were described. An increase in activity of these enzymes was observed in the organs mentioned 24 hours after sublethal (650 R) as well as after supralethal (1950 R) irradiation; while a decrease in the enzyme activity was observed during the further course of the acute radiation sickness in almost all of the organs investigated. The results were compared with others which had been done so far and a certain conformity of the results could be found. The results represented a part of an extensive study series concerning histo- and biochemical determination of enzymes in organs of irradiated small and large animals. (auth)

**20105** METABOLISM AND TOXICITY OF THERAPEUTIC CHELATING AGENTS. PART 5. PHYSIOLOGICAL DILUTION SPACE OF EDTA AND DTPA. Bohne, Felicitas; Harmuth-Hoene, Anna-Elisabeth; Kuerzinger, Klaus; Havlicek, Frantisek (Kernforschungszentrum, Karlsruhe, Ger.). Strahlentherapie, 136: 609-16(Nov. 1968). (In German).

The serum clearance of $^{14}C$-labeled Ca-EDTA as well as Ca- and Zn-DTPA as a function of dose was determined in rats. The clearance was multiexponential: $\geq$99% of the chelates were cleared with a half-time of 17 minutes while the remaining fraction, which was larger in the case of EDTA than with DTPA, had a half time of $\geq$20 hours. Chelate doses and the kind of chelated metal ion were without influence. The physiological dilution space of the chelates corresponded to the extracellular water. There was only a very slight intracellular accumulation of $^{14}C$. It could be shown by experiments with ligated kidney vessels, as well as by a compartmental analysis and by electrophoretic separation of blood plasma that the slow term of the clearance function was not due to a rediffusion of the chelates from the intracellular space but to binding of the chelates or their metabolites, respectively, by the plasma proteins. (auth)

**20106** THE TURNOVER OF $^{65}Zn$ DURING THE EARLY EMBRYONAL DEVELOPMENT OF THE SEA URCHIN PARACENTROTUS LIVIDUS LAM. Ozretic, B.; Krajnovic, M. (Inst. Ruder Boskovic, Rovinj, Yugoslavia). Rev. Int. Oceanogr. Med., 11: 101-6(1968).

From 3rd International Conference on Medical Oceanography, Nice, France. See CONF-670977.

The variations in the rate of $^{65}Zn$ uptake by fertilized sea urchin eggs during the course of development were studied. Three phases were distinguished. The first with the greatest uptake rate was recorded immediately after the fertilization. This was followed by a period of stasis when little or no increase of radioactivity was recorded. The third phase started after the hatching of blastulae when the uptake rate was rapidly increased. Possible interpretations of results are discussed. (H.L.W.)

**20107** EXPERIMENTAL RESEARCH ON ACCUMULATION OF RADIONUCLIDES BY MARINE ORGANISMS. Avargues, M.; Ancellin, J.; Vilquin, A. (CEA, La Hague, France). Rev. Int. Oceanogr. Med., 11: 87-100(1968). (In French).

From 3rd International Conference on Medical Oceanography, Nice, France. See CONF-670977.

The introduction into the marine environment of liquid radioactive wastes constitutes a potential risk of irradiation for people. The nature of this risk varies but one of the most important aspects is the contamination of marine products used by the man for food. The importance of this process depends on many factors, physical ones such as the dispersion of effluents by marine currents, chemical ones such as the processes of floculation and sedimentation of radionuclides, and biological ones. The value of the accumulation factors of radionuclides by various constituents of the marine biosphere is of particular interest. This data, which determines the coefficient of radiotoxicological hazard of contaminated food can be studied in two essential ways: the observation in situ based on a systematic control of critical species where disposals are made and also, on experimental study in the laboratory. The establishment of this method causes some difficulties, which it is necessary to control in order to extrapolate from an artificial media to the natural media. The authors relate the results of different experiments made in aquariums on some comestible species like pink shrimp, oyster, mussel, and clam, using various fission products such as $^{137}Cs$, $^{144}Ce$, and $^{106}Ru$ that are present in the radioactive wastes from the Hague plant. These results are discussed in relation to the data recorded by in situ observation at other sites of radioactive waste disposal. The significance of the experimental research on accumulation factors in aquariums in the field of marine pollution is shown. (C.O.)

**20108** STUDIES ON CONTAMINATION OF CIONA INTESTINALIS (TUNICATA) WITH $^{131}I$ AND $^{59}Fe$. Battani, M.; Chambost, M. D.; Leandri, M. (Inst. of Tropical Hygiene and Social Medicine, Marseille). Rev. Int. Oceanogr. Med., 11: 71-86 (1968). (In French).

From 3rd International Conference on Medical Oceanography, Nice, France. See CONF-670977.

Analysis of the kinetics of accumulation and retention of these radionuclides and the repartition of these radionuclides in the different organs of Ciona is given. Ciona concentration ratios of $^{131}I$ and $^{59}Fe$ were also determined. (auth)

**20109** BASIC RADIATION BIOLOGY. Pizzarello, Donald J.; Witcofski, Richard L. Philadelphia, Lea and Febiger, 1967. 308p. $9.50.

Basic principles of physics and biology necessary for understanding the effects of radiation on living organisms are presented. The book has developed from courses taught by the authors in the Bowman Gray School of Medicine at Wake Forest University. The first part, Review of Pertinent Physics, describes techniques of irradiation and methods of measuring radiation doses. The second part, Interaction of Radiations with Living Systems, includes discussions of the target theory, metabolic expression of radiation injury, genetic effects, bone marrow and gastrointestinal syndromes, late effects, and effects on immunity. Many excellent diagrams and tables are included. The book is directed to college undergraduates, beginning graduate students, radiologists, and radiation physicists with interests in radiation biology. (H.L.W.)

**20110** IRRADIATION OF A DOG WITH MYELOGENOUS LEUKEMIA. Cameron, Thomas P.; Kinard, Roy; Johnson, Ralph (National Cancer Inst., Bethesda, Md.). J. Amer. Vet. Med. Ass., 154: 279-82(Feb. 1, 1969).

The effects of whole-body irradiation on hematologic parameters were studied in a dog with myelogenous leukemia given two series of exposures for a total of 360 R. A slight clinical improvement preceded a gradual decline of 2½ month. During that period, the leukocyte count decreased from 104,000 to 10,000/$mm^3$. Hematopoietic damage was demonstrated as the erythrocytes decreased from 4,200,000 to 1,400,000/$mm^2$ and the packed cell volume (PCV) fell from 36 to a low of 10%. The spleen was enlarged at necropsy. The radiation therapy (60 R) given in the last week of life may have precipitated death. While the leukocyte count was not appreciably affected, the PCV continued to decline, and the last PCV reading before death was 12%. This was the lowest point reached, except for a 10% PCV one month previous to death that appeared directly related to the initial massive irradiation series (300 R). This condition can be utilized as an animal model system for evaluating therapies. (BBB)

**20111** EFFECTS OF γ-RAY IRRADIATION UPON MILK AND PROTEINS. PART 2. CHANGES IN RELATIVE VISCOSITIES AND GELATION OF CASEIN SOLUTIONS IRRADIATED WITH γ-RAYS. Umemoto, Yaichiro; Aoki, Takayoshi (Nagoya Univ., Japan). Nippon Nogeikagaku Kaishi, 42: 454-60(Aug. 1968). (In Japanese).

Relative viscosities of casein solutions irradiated with γ-rays showed anomalous changes. For 1% casein solutions irradiated up to 2.5 Mrads, viscosities increased considerably, but they decreased gradually up to 5 Mrads. 1.5% casein solutions were gelled at above 1.6 Mrads. Changes in viscosities were remarkably dependent on casein concentrations, in particular, and these solutions of over 1.5% gelled at 2.5 Mrads. The relationships between casein concentrations and doses indicated that 3 to 4% gave the minimum dose required to gel (2.9 Mrads). Relative viscosities tended to decrease with increasing doses, by adding suitable amounts of lactose. For non-irradiated solutions, viscosities increased with increasing lactose (1 to 5%), but they were lower than for solutions not containing lactose. When small amounts of lactose were added (below 0.3%), they were higher than for non-irradiated, lactose-containing solutions. Particularly, these solutions gelled at 5 Mrads. Relative viscosities and pH of non-irradiated casein solutions containing appropriate amounts of $CaCl_2$ lowered together. For 1% casein solutions containing 4 mM $CaCl_2$, viscosities tended to lower at below 0.8 Mrad, and increased considerably at above 0.8 Mrad. Lactose in solutions had more remarkable effects on viscosities by coexistence of lactose with $CaCl_2$. At 0.8 and 1.6 Mrads, minimum viscosities were obtained at 6 and 4 mM $CaCl_2$ added, respectively. Addition of 6 and 12 mM $Na_2HPO_4$ increased noticeably their viscosities with increasing doses. Gelation of casein solutions was accelerated by existence of both $Na_2HPO_4$ and $CaCl_2$ during irradiation. (NSA of Japan)(auth)

**20112** $^{241}Am$ IN THE BLOOD: IN VIVO AND IN VITRO OBSERVATIONS. Bruenger, F. W.; Stevens, W.; Stover, Betsy J. (Univ. of Utah, Salt Lake City). Radiat. Res., 37: 349-60(Feb. 1969).

The concentration in canine blood of trivalent $^{241}Am$ that had been injected intravenously decreased at a rate comparable with those of divalent alkaline earths. A small fraction of the $^{241}Am$ was associated with blood cells, but the major part was in the serum. Complexes with serum proteins were demonstrated in sera obtained at 1 and 5 minutes after injection. Americium-241 complexes with both transferrin and albumin were identified and isolated in in vitro experiments with human sera. The AmIII complex with transferrin is less stable under physiological conditions than either the FeIII- or PuIV-transferrin complex. Evidence was obtained for a third AmIII-protein complex. (auth)

**20113** REPAIR REPLICATION OF MAMMALIAN CELL DNA EFFECTS OF COMPOUNDS THAT INHIBIT DNA SYNTHESIS OR DARK REPAIR. Cleaver, J. E. (Univ. of California, San Francisco). Radiat. Res., 37: 334-48(Feb. 1969).

After irradiation with ultraviolet light, HeLa cells undergo repair replication by which small numbers of bases are inserted into parental strands of DNA molecules. Repair replication is also observed autoradiographically by the incorporation of thymidine or deoxycytidine into DNA during the $G_1$, $G_2$, and mitotic stages of the cell cycle. The effects of a number of compounds, classified into three groups according to their mode of action, on repair replication were determined quantitatively. Compounds that inhibit the synthesis of precursors of DNA inhibit semiconservative replication but do not inhibit repair replication. Compounds that bind to DNA inhibit both semiconservative and repair replication. Iodoacetate and cycloheximide also inhibit both semiconservative and repair replication. From a comparison of the effects of acriflavine and caffeine on repair replication in HeLa cells and on the survival of uv-irradiated mouse L cells, it is concluded that repair replication is probably not the only form of repair mechanism in mammalian cells. There appears to be, at least in mouse L cells, a caffeine-sensitive repair process confined to the S phase that does not involve repair replication. (auth)

**20114** INACTIVATION OF CRYSTALLINE ENZYMES BY PHOTODYNAMIC TREATMENT AND GAMMA RADIATION. Hopkins, T. R.; Spikes, John D. (Univ. of Utah, Salt Lake City). Radiat. Res., 37: 253-60(Feb. 1969).

The quantum yields of photodynamic inactivation were determined for acetylated trypsin, carboxypeptidase, catalase, α-chymotrypsin, β-chymotrypsin, γ-chymotrypsin, δ-chymotrypsin, lysozyme, papain, peroxidase, ribonuclease, subtilisin, and trypsin by using methylene blue, eosin Y, and FMN as sensitizers. Reaction mixtures were buffered at pH 7.9 and maintained at 15°C while being illuminated with monochromatic light. With the exception of peroxidase, which was not inactivated at all under our experimental conditions, the quantum yields for the photodynamic inactivation of the different enzymes ranged from $1.0 \times 10^{-1}$ to

$1.3 \times 10^{-2}$. In general, the quantum yields for the inactivation of a given enzyme were largest with FMN, intermediate with eosin Y, and smallest with methylene blue. Within experimental error, the esterase and protease activities of the chymotrypsins and trypsins showed the same sensitivity to photodynamic treatment. Gamma-radiation inactivation yields for the above enzymes were also determined; yields with the different enzymes ranged from $1.7 \times 10^{-5}$ to $1.7 \times 10^{-2}$ molecule inactivated per electron volt of gamma radiation absorbed. The relative sensitivities to photodynamic treatment and to gamma radiation are roughly the same for most of the enzymes studied. (auth)

**20115** STUDIES ON STAGE RADIOSENSITIVITY AND DNA SYNTHESIS OF CHROMOSOMES IN CULTURED HUMAN CELLS. Kang, Yung Sun; Park, Sang Dai (Seoul National Univ., Korea). Radiat. Res., 37: 371-80(Feb. 1969).

Stage radiosensitivity and DNA synthesis were studied in x-irradiated human kidney cells by means of thymidine-$^3$H labeling and autoradiography. The frequency of diplochromosomes tends to decrease, whereas the polyploids increase with the time after irradiation. Though aberrations were distributed throughout in the cells that were in both S and $G_2$, the frequency of chromatid aberrations in irradiated cells reached a peak at $G_2$, followed by late S, and early and mid-S stages were the lowest. The data showed an increase in chromatid deletion and chromatid exchange as the cell proceeded to $G_2$, and the frequency of isochromatid deletion was constant from S throughout $G_2$. The rate of DNA synthesis and labeling intensities in irradiated cells was lower than that in the control. (auth)

**20116** REPAIR REPLICATION, UNSCHEDULED DNA SYNTHESIS, AND THE REPAIR OF MAMMALIAN DNA. Painter, R. B.; Clever, J. E. (Univ. of California, San Francisco). Radiat. Res., 37: 451-66(Mar. 1969).

Several kinds of cultured mammalian cells have been examined after exposure to ultraviolet light to determine if repair replication and unscheduled DNA synthesis occur. All kinds thus far examined, with the exception of cells derived from patients with Xeroderma pigmentosum, show both phenomena. Cells of human origin exhibit both phenomena to a greater extent, however, than do cell lines derived from rodents. There is at least a rough correlation of the extent of repair replication with the extent of unscheduled synthesis suggesting that both are manifestations of the same process. Both phenomena also occur after exposure to visible light of HeLa cells with bromouracil-substituted DNA. The results are discussed in terms of the possible role of these phenomena in the repair of damaged DNA. (auth)

**20117** MECHANISM OF RADIATION HEMOLYSIS IN HUMAN ERYTHROCYTES. Kollmann, George; Shapiro, Bernard; Martin, David (Albert Einstein Medical Center, Philadelphia). Radiat. Res., 37: 551-66(Mar. 1969).

Human bank blood erythrocytes were given hemolyzing (16 to 50 kR) exposures of $^{60}$Co gamma rays, suspended in various media, and maintained at 5°C for 20 hours. Hemolysis occurred in isotonic NaCl but was prevented or reduced in isotonic choline chloride and in hypertonic NaCl or KCl. Prior to hemolysis in isotonic NaCl, the cells rapidly lost potassium and accumulated sodium. Although irradiated suspensions of cells in choline chloride did not hemolyze, they lost potassium. 2-Mercaptoethylguanidine (MEG) and reduced glutathione (GSH), which does not enter cells, reduced hemolysis and potassium loss when added to the suspensions before irradiation. Radiation caused a marked decrease in membrane sulfhydryl groups. Blockage of membrane sulfhydryl groups by p-chloromercuribenzoate (FCMB) and p-chloromercuribenzene sulfonate (PCMBS), which does not enter the cells, mimicked radiation by causing potassium loss and hemolysis. PCMBS-induced hemolysis was prevented by suspension of the cells in isotonic choline chloride. Removal of PCMBS from the cell membrane by MEG stopped hemolysis. The results indicate that radiation-induced hemolysis is an osmotic hemolysis due to the partial destruction of the natural barrier to the sodium and potassium movements across the cell membrane. The destruction of this barrier somehow involves the destruction of membrane sulfhydryl groups. (auth)

**20118** KINETICS OF FORMATION AND SPLITTING OF URACIL DIMER IN TRANSFER RNA IRRADIATED BY ULTRAVIOLET. Matsukage, Akio; Kawade, Yoshimi; Fukutome, Hideo (Kyoto Univ.). Radiat. Res., 37: 617-26(Mar. 1969).

The amount of uracil dimer formed in yeast transfer RNA by ultraviolet (253.7 mμ) irradiation was determined as a function of dose. It showed a transient increase followed by a subsequent gradual decrease, as expected. The cross section of dimer formation was estimated to be $17 \times 10^{-4}$ cm$^2$/erg. The kinetics of the uracil photoreaction other than dimer were determined as the total change in uracil minus dimer and were found to be first order. The cross section of this reaction, most likely hydration, was evaluated to be $4.0 \times 10^{-4}$ cm$^2$/erg. (auth)

**20119** A PHOTOMETRIC ANALYSIS OF ULTRAVIOLET PHOTOREACTION KINETICS OF TRANSFER RNA. Fukutome, Hideo; Wada, Akira; Kawade, Yoshimi (Kyoto Univ.). Radiat. Res., 37: 599-616(Mar. 1969).

The kinetics of photoreactions that transfer RNA (tRNA) undergoes on ultraviolet (253.7 mμ) irradiation were investigated. For this purpose, a spectrophotometric technique was developed to measure the changes in amount of uracil and cytosine residues in tRNA separately, and applied to yeast tRNA irradiated under various conditions of pH and salt composition. The photoreaction kinetics of uracil residues were found to consist of two phases with different values of apparent cross sections, which are presumed to be due to occurrence of two reactions, dimer formation and hydration. The cross sections of these reactions were shown to become larger at pH below 7, and to decrease when secondary structure develops in tRNA. The photoreaction of cytosine residues was shown to depend considerably on their state of ionization. The photoproduct produced in the uncharged state, presumably a hydrate, was shown to revert almost completely by mild heating, but the one produced in the charged state reverted rather poorly. (auth)

**20120** RADIATION-INDUCED HYDROGEN ISOTOPE EXCHANGE IN SOLUTIONS OF POLYAMINO ACIDS. Southern, E. M. (Meat Research Inst., Cambridge, Eng.). Radiat. Res., 37: 590-8(Mar. 1969).

The exchange of tritium from tritiated water into poly-α,L-glutamic acid, poly-D,L-alanine, and poly-L-proline was studied to test the possibility of a back-reaction between reducing radicals and free radicals formed from the polyamino acid. In all three polyamino acids, tritium was incorporated with $G \cong 0.1$ to 0.2, and a high proportion was shown to be incorporated by exchange at C−H bonds. Some incorporation resulted from C−C bond breakage and some possibly from C−N bond breakage. Nitrate ions suppressed incorporation into poly-α-L-glutamic acid and poly-D,L-alanine, suggesting that reducing radicals played a part in the incorporation. (auth)

**20121** CORRELATION BETWEEN THE BREAKDOWN OF DEOXYRIBONUCLEIC ACID AND RADIOSENSITIVITY OF ESCHERICHIA COLI. Trgovcevic, Zeljko; Kucan, Zeljko (Inst. Ruder Boskovic, Zagreb). Radiat. Res., 37: 478-92(Mar. 1969).

The variations of sensitivity to gamma irradiation during the progression of E. coli B and E. coli $B_{s-2}$ through various phases of growth were compared with the ability of the same cells to break down their DNA during postirradiation incubation. Degradation of DNA was measured under the conditions that minimize the reincorporation of breakdown products. Both the survival and the DNA degradation varied during the cell progression in a very similar manner: the lowest radiosensitivity and the lowest DNA degradation were found in the stationary phase, while the cells from midlogarithmic phase displayed the lowest survival and the most extensive degradation. Among several strains examined, the strains of higher radioresistance showed lower ability to break down their DNA; moreover, radiosensitive phases of their growth displayed also higher degradation of DNA. A general correlation showing a direct proportionality of the percentage of degradation and the negative logarithm of survival was obtained. It is proposed that the degradation of DNA in E. coli is not a part of the repair process. (auth)

**20122** THE $^{131}$I METABOLISM OF GUINEA PIGS. Muro, T.; Koecke, K. (Staedtische Krankenanstalten, Wuppertal-Barmen, Ger.). Endokrinologie, 52: 88-96(1967). (In German).

The $^{131}$I metabolism of guinea pigs and humans was compared. The major difference observed was that the guinea pigs had a very low uptake of $^{131}$I, which amounted to between 6 and 15% after 24 hr. This level was maintained for ~8 days afterwards. The $^{131}$I contained in the entire body of each animal was from 15 to 38% of the dose given. After the animals were stressed, there was a rapid increase in concentration of triiodothyronine ($T_3$) in the thyroid gland and serum. The concentration ratios of $T_3$ and thyroxine increased relatively constantly. The guinea pigs' thyroid glands appeared to have a high clearance rate for the peripheral decomposition products of the metabolically active thyroid hormones. Generally, metabolism of I compounds by the guinea pig's thyroid gland was considerably lower than in humans. (BBB)

**20123** THE EFFECT OF STABLE STRONTIUM ON THE METABOLISM OF $^{90}$Sr AND CALCIUM IN THE GROWING RAT. Lang, K.; Schmidt, B. (Johannes-Gutenberg-Univ., Mainz). Z. Ernaehrungswiss., 9: 67-82(May 1968). (In German).

Distribution and excretion of $^{90}Sr$ was studied in rats fed 1800 ± 100 pCi $^{90}Sr$/g Ca and stable Sr. The feed contained 4 to 40,000 ppM of Sr. The animals that received the highest Sr dosage survived only 10 days. Changes in food intake, wt loss, bone destruction, and mineral turnover were observed at intake of 4000 ppM of Sr. At this level, 15% of the Sr was resorbed, 10 to 16% was excreted in urine, and 4 to 5% was retained in skeleton. Resorption of Ca was unaffected by Sr intake, and amounted to 30 to 40%. The Ca replaced by Sr in bone was excreted in the urine. The control animals incorporated ~25% of the Ca into bone, but only ~20% was retained in rats that received 4000 ppM of Sr. Resorption of $^{90}Sr$ was not affected by the stable Sr, but incorporation of $^{90}Sr$ into bone was reduced by ½, the blood level of $^{90}Sr$ was increased, and urinary excretion of $^{90}Sr$ increased from 8 up to ~10%. Retention of $^{90}Sr$ by bone was decreased from 5 or 6% to 3 to 5%. The Sr intoxication produced was not accompanied by marked decontamination of the $^{90}Sr$ from the skeleton. (BBB)

**20124** EFFECT OF $^{60}Co$ GAMMA IRRADIATION ON THE UTILIZATION OF ENERGY, PROTEIN, AND PHOSPHORUS FROM WHEAT BRAN BY THE CHICKEN. Moran, E. T. Jr.; Summers, J. D.; Bayley, H. S. (Univ. of Guelph, Ont.). Cereal Chem., 45: 469-79(Sept. 1968).

In view of proposed deinfestation of wheat by ionizing radiation, the effect of $^{60}Co$ treatment of wheat bran at doses of 0.5 and 5.0 Mrad on its nutritional value was examined. Initial studies on metabolizable energy and amino acid composition showed no outstanding differences between treatments, and later studies permitted accurate isocaloric formulation and optimal supplementation of assay diets. Feeding the respective brans to chicks (1 to 3 weeks old) in semipurified diets as sole source of protein and phosphorus revealed significant improvements in growth and ratio of grain to feed consumed when amino acid supplementation was termed optimal and bran was irradiated. Also noted when bran was irradiated were significant improvements in net protein and P utilization. Although utilization of P was greater at the 5.0-Mrad treatment level than with 0.5 Mrad, this was not true for net protein utilization (NPU). On the basis of failure to demonstrate differences in growth, feed efficiency, or NPU between birds fed control and irradiated bran diets, when cystine was derived exclusively from the associated protein and the only limiting nutrient, it seemed improbable that this disulfide unit was measurably affected by irradiation. (BBB)

**20125** STUDIES OF IRON KINETICS USING A LINEAR SCANNER. I. DISTRIBUTION OF SITES OF UPTAKE OF PLASMA IRON IN HEMATOLOGICAL DISORDERS. Alfrey, Clarence P. Jr.; Lynch, Edward C.; Hettig, Robert A. (Veterans Administration Hospital, Houston, Tex. Baylor Univ., Houston, Tex.). J. Lab. Clin. Med., 73: 405-17(Mar. 1969).

Quantitative total body linear scanning 24 hours after intravenous injection of radioiron was performed on 132 persons to identify sites of active marrow and to assess hepatic and/or splenic uptake of plasma iron. In normal subjects radioactivity was detected principally over the thorax, abdomen, pelvis, and proximal femora indicating a distribution of marrow approximating previous anatomical studies. Erythroid activity was found in the distal portions of the lower extremities frequently in patients with polycythemia vera and congenital hemolytic anemia. Increased abdominal radioactivity representing uptake of a greater than normal fraction of plasma iron by liver and/or spleen occurred in hypoplastic anemia, acute leukemia, myelophthisic anemias, hemochromatosis, and myeloid metaplasia. Among disorders with increased abdominal uptake of radioiron, myeloid metaplasia was distinguished by accelerated clearance rate of plasma iron by abdominal organs. In persons with normal marrow distribution a significant linear relationship was established between red blood cell incorporation of radioiron and the fraction detected over each of three body segments —chest, abdomen, and pelvis. Interpretation of these relationships indicated total body erythropoiesis was distributed proportionately among each of the three segments without regard to the level of erythropoiesis. The distribution of erythropoietic sites was: 28 per cent in the chest, 25 per cent in the abdominal segment, and 34 per cent in the pelvis. A method was presented by which the fraction of radioiron incorporated by all erythropoietic cells could be estimated by linear scanning. (auth)

**20126** USE OF A DOUBLE ERYTHROCYTE LABEL TECHNIQUE TO MEASURE RED CELL SURVIVAL OF ACD AND ACD-ADENINE PRESERVED BLOOD IN TRAUMA PATIENTS. Taube, R. R.; Matsuda, T.; Baker, R. J.; Dern, R. J.; Elwyn, D. H.; Shoemaker, W. C. (Univ. of Illinois, Chicago. Hektoen Inst. for Medical Research, Chicago. Loyola Univ., Chicago. Mt. Sinai School of Medicine, New York). J. Lab. Clin. Med., 73: 425-31 (Mar. 1969).

Blood stored in ACD-adenine solution for 32 to 36 days (average 35 days) when transfused into acutely traumatized patients had an average 24 hour red cell survival of 75 per cent. This was equivalent to the 75 per cent red cell survival of blood stored in ACD solution for 12 to 21 days (average 18 days). The average 24 hour cell survival of the ACD-adenine stored blood injected back into the donor was equivalent to that observed in the trauma patient. This suggested that transfused red cells were handled almost as well by the acutely injured patient as they were by the uninjured subject. The rate of decrease in red cell radioactivity of the patient's own cells labeled with $DFP^{32}$ averaged 1.24 per cent per day. After the initial 24 hour red cell loss, the ACD-adenine preserved cells independently labeled with $Cr^{51}$ had equivalent rates of decreasing radioactivity (1.3 per cent per day). Similar values were obtained in ACD stored blood given to traumatized patients. This suggested that either ACD or ACD-adenine transfused blood cells after the initial 24 hour period were not destroyed at significantly faster rates than the patient's own cells. The rates of radioactivity decline in the traumatized patients were somewhat greater than values reported in normal subjects; this suggested that there were somewhat greater rates of red cell production in the acutely injured patient. (auth)

**20127** GROSS UPTAKE OF RADIONUCLIDES BY MARINE MICRO-ORGANISMS IN BATCH CULTURE. Umezu, T.; Saiki, M. Naikai-ku Suisan Kenkyusho Kenkyu Hokoku, No. 24, 1-9 (1967). (In Japanese).

Relative values are given of the gross uptake of radioisotopes from sea water by microorganisms. (UK) (auth)

**20128** THE EFFECT OF CARRIER AND DTPA ON THE DISTRIBUTION OF $^{147}Pm$ IN THE RAT. Grigorescu, St.; Weber, K. M. (Kernforschungszentrum, Karlsruhe, Ger.). Atomkernenergie, 14: 147-8(Mar.-Apr. 1969).

Addition of cerium as carrier enhances the deposition of $^{147}Pm$ in the liver and spleen of the rat. Autoradiographically, a spotty distribution pattern in these organs is observed. DTPA has less effect than the carrier-free radionuclide. (auth)

**20129** GLYCOLYSIS IN RAT BRAIN TISSUE SLICES FOLLOWING NEONATAL HEAD X IRRADIATION: RELATION OF REGIONAL DIFFERENCES TO THE LDH:GPDH RATIO. de Vellis, Jean (Univ. of California, Los Angeles). J. Neurochem., 15: 1057-60(Oct. 1968).

The effect of neonatal head irradiation on the aerobic formation of lactate in cortex, brain stem, and medulla slices was studied. Wistar rats 2 days old received 750 R x irradiation of the head and glycolysis was measured at 20 days of age. Irradiation enhanced the synthesis of lactate in medulla slices by 80% under standard conditions and 107% in the presence of chloral. Cortex and brain stem slices of normal or irradiated rats produced twice as much lactate in the presence of chloral as in its absence. In contrast, the increase with medulla slices was only about 30% for control rats and 50% for irradiated rats. Therefore, irradiation seemed to sensitize medulla slices to the action of chloral. The enhancement of the aerobic formation of lactate in irradiated medulla could result from an increased level or activity of glycolytic enzymes or a failure of regulatory mechanisms controlling glycolysis. Lactate dehydrogenase (LDH) and glycerolphosphate dehydrogenase (GPDH) compete for NADH generated by glycolysis. A change in the relative concentration of these two enzymes in favor of lactate dehydrogenase could result in lactate accumulation. Lactate is a dead-end product of metabolism and to be metabolized it must be reconverted to pyruvate, a process which requires $NAD^+$. These two enzymes were assayed at 20 days of age in the brain areas studied. The specific activity (units/mg protein) of GPDH was lower in irradiated than in control brain areas. Medulla had the highest deficiency (42% decrease). LDH specific activity remained essentially unchanged for cortex and brain stem, but was higher in irradiated than in control medulla. The ratio of LDH to GPDH was slightly higher in irradiated cortex and brain stem than in their respective controls, but it more than doubled in irradiated medulla as compared to control medulla. (BBB)

**20130** ANALYSIS OF PHOTOENZYMATIC REPAIR OF UV LESIONS IN DNA BY SINGLE LIGHT FLASHES. II. IN VIVO STUDIES WITH ESCHERICHIA COLI CELLS AND BACTERIOPHAGE. Harm, Walter; Harm, Helga; Rupert, Claud S. (Southwest Center for Advanced Studies, Dallas). Mutat. Res., 6: 371-85(Nov.-Dec. 1968).

Intracellular complexes of uv lesions in DNA with molecules of photoreactivating enzyme (PRE) in E. coli can be photolysed with a probability close to one by single light flashes of about one millisecond duration. The observed photoreactivation (PR) effect permits the number of PRE-substrate complexes present at the time of the flash to be determined on the following basis: the number of PRE-substrate complexes equals the number of lesions repaired;

the number of photorepairable uv lesions present in DNA equals the number of pyrimidine dimers recoverable from acid hydrolysates; a uv dose of one erg · $mm^{-2}$ of 2537 Å radiation causes the formation of approximately 6.5 dimers per E. coli chromosome; the observed PR effect can be expressed by the formal dose-reduction, i.e., by the reduction in the number of dimers. The kinetics of intracellular complex formation can be followed by varying the time interval between uv irradiation and flash reactivation. Stationary phase $B_{s-1}$ cells, irradiated with 4.8 erg · $mm^{-2}$ form a maximum number of complexes within approximately 5 min at room temperature, 50% of them being formed within the first 10 to 15 sec. For greater uv doses (6.4 to 24 erg · $mm^{-2}$) the maximum number formed reaches a constant limiting value of 20, indicating that this is approximately the number of PRE molecules in these cells. Experiments with sequential flashes at various temperatures between 2° and 44° show that both the maximum extent of complex formation and the photolytic rate constant are temperature-independent in this range. Hence the usually observed temperature-dependence of PR under conditions of continuous illumination reflects the temperature-dependence of the complex formation only. Extensive PR effects with single light flashes were also found in uv-irradiated phage T1 after infection of unirradiated $B_{s-1}$ cells. The effects are much smaller in irradiated host cells due to competition by the bacterial DNA. Creating the competitive substrate after the phage DNA has reacted with the PRE results in a time-dependent decrease of the PR effect in phage as the enzyme equilibrates between the host-cell and phage DNA's. The slow rate of equilibration indicates a relatively high stability of the complexes in the dark. A heterogeneity of the photoproducts is evident with regard to both complex formation and stability. Comparative experiments with phage infecting other host strains indicate that the number of PRE molecules in strain B/r equals that in $B_{s-1}$, but is lower in the K12 derivatives AB 1157, AB 2437 and AB 2480. (auth)

**20131** ANALYSIS OF PHOTOENZYMATIC REPAIR OF UV LESIONS IN DNA BY SINGLE LIGHT FLASHES. I. IN VITRO STUDIES WITH HAEMOPHILUS INFLUENZAE TRANSFORMING DNA AND YEAST PHOTOREACTIVATING ENZYME. Harm, Helga; Rupert, Claud S. (Southwest Center for Advanced Studies, Dallas). Mutat. Res., 6: 355-70(Nov.-Dec. 1968).

The photoenzymatic repair of ultraviolet (uv) lesions in DNA is a photochemical reaction which occurs in an enzyme–substrate complex between these lesions and photoreactivating enzyme (PRE). It is shown here that high intensity flash illumination (duration of the order of 1 millisecond) causes this repair in essentially all enzyme–substrate complexes present at the time. This fact allows several kinds of studies. By applying the flash at timed intervals after mixing PRE and uv-irradiated bacterial transforming DNA, the formation of enzyme–substrate complex can be observed directly. The process takes of the order of minutes for its completion at the usual reaction concentrations, and the effect of changing concentration shows that most of this time is required for the extremely dilute reactants (~$10^{-9}$ M) to encounter each other in solution. When a sequence of flashes is applied with the uv lesions in excess, the resulting stepwise repair permits complex formation to be studied at each level of recovery, from the first set of lesions erased to the last. The result shows that the lesions are heterogeneous with respect to rate of complex formation. The rate of complex formation depends on temperature, but once a complex has been formed at 37° it does not rapidly dissociate on shifting the temperature to 2°. Repeating the experiments at lower light intensity, where not all the complexes present are repaired at each flash, then shows that the actual photochemical process in the complex is temperature-independent over the 2–37° range, at least for the most rapidly complexing lesions. When PRE is allowed to complex with irradiated transforming DNA in the dark, and irradiated non-transforming DNA is subsequently added flashes applied at various times after this addition allow the dark dissociation of enzyme–substrate complexes to be followed. Comparison with the converse experiment, in which PRE is first complexed with lesions on non-transforming DNA, shows that some complexes are extremely stable, the enzyme preferentially remaining on the first DNA with which it forms a complex even after 2 h. Complexes with uv lesions on the synthetic polydeoxynucleotides dA:dT and dG:dC are more stable than most complexes with natural DNA. Measurement of complex formation under conditions of DNA excess, where essentially all the enzyme is bound, permits determination of the number of enzyme molecules relative to the number of uv lesions. The reasonable assumption that the number of lesions equals the number of pyrimidine dimers recoverable from the DNA then gives an absolute count. Provided the molecular weight of $3 \cdot 10^4$ given by Muhammed is approximately correct, the proportion of pure enzyme to total protein in crude yeast extract is about $2 \cdot 10^{-6}$. (auth)

**20132** DNA-STRAND BREAKS AND REJOINING FOLLOWING EXPOSURE OF SYNCHRONIZED CHINESE HAMSTER CELLS TO IONIZING RADIATION. Humphrey, R. M.; Steward, D. L.; Sedita, B. A. (Univ. of Texas, Houston). Mutat. Res., 6: 459-65(Nov.-Dec. 1968).

Radiation-induced single strand breaks in the DNA of synchronized Chinese hamster cells and the rejoining of broken pieces were investigated by the use of alkaline sucrose density gradients. The weight average molecular weight of denatured DNA was determined for cells in mitosis, $G_1$, and S phase following $\gamma$ irradiation and post-irradiation incubation. The data presented support the conclusion that the processes that are responsible for the rejoining of broken pieces of DNA are present and functional during all phases of the cell cycle, including mitosis. The molecular weight of denatured DNA from unirradiated control cells consisted of a wide distribution of small and large pieces ranging from about $10 \cdot 10^6$ to $250 \cdot 10^6$ with a weight average molecular weight of 50 to $55 \cdot 10^6$. The data are consistent with the hypothesis that mammalian cell chromosomal DNA is arranged in a series of small units held together by linker molecules which are labile to alkaline conditions. (auth)

**20133** $^{14}C$ ISOTOPE EFFECT IN THE PYROLYSIS OF THE SINGLY LABELED DIMETHYL ETHER. Zielinski, Mieczyslaw (Univ. of Warsaw). Nukleonika, 13: 1061-6(1968). (In Polish).

The $^{14}C$ isotope effect in the gas-phase pyrolysis of $^{14}C$ singly labeled dimethyl ether is reported. Molecules of ether containing $^{12}C$ atoms only decompose about 1% faster than $^{12}CH_3-O-{}^{14}CH_3$ isotopic molecules. It was found that the measured $^{14}C$-isotope effects are consistent with the free radical mechanism of decomposition of the dimethyl ether. The $^{14}C$ isotopic fractionation observed is determined by the kinetic isotope effect in the C–H bond rupture. It may be concluded that there is no fast hydrogen migration in the free radical $\cdot CH_2-O-CH_3$ and that the two isomeric isotopic radicals $^{12}CH-O-{}^{13}CH_3$ and $^{13}CH_2-O-{}^{12}CH_3$ preserve their identities during their finite lives. (auth)

**20134** LANGAT VIRUS ENCEPHALITIS IN MICE. II. THE EFFECT OF IRRADIATION. Webb, H. E. (St. Thomas's Hospital, London); Wight, D. G. D.; Wiernik, G.; Platt, G. S.; Smith, C. E. G. J. Hyg., 66: 355-64(Sept. 1968).

In view of the known suppressive action of irradiation on the immune response, experiments were carried out to evaluate the role of antigen-antibody reactions in the development of viral encephalomyelitis. Irradiation by $^{60}Co$ with a whole-body dose of 200 RAD or more increased the sensitivity of mice to intraperitoneal infection with Langat virus so that the $LD_{50}$ was increased to about that of the intracerebral $LD_{50}$. In mice given 500 RAD before infection: viraemia was prolonged by about 5 days; the IgM response was depressed; the IgC response was delayed by about 3 days and depressed in titer; virus concentration in the brain rose continuously until death on about the tenth day while in the controls it reached a peak on the fifth day then subsided; histological changes in the central nervous system were delayed and minimal even at death; irradiated mice died with little evidence of paralysis while the controls died with severe paralysis. In irradiated mice, protection was observed when antibody was administered on the third day following infection. Antibody given on the 3 days after infection to control mice aggravated the disease. It was concluded that neuronal damage is caused both by virus multiplication in neurons and by damage superimposed by inflammatory changes with associated edema and hypoxia. The inflammatory changes appear to be caused by an allergic reaction to virus-antibody complexes formed in the circulation and in the central nervous system. (BBB)

**20135** RADICALS FORMED BY ELECTRON TRANSFER TO PYRIMIDINE DERIVATIVES. Holroyd, R. A.; Glass, J. W. (Atomic International, Canoga Park, Calif.). Int. J. Radiat. Biol., 14: 445-52(Dec. 1968).

The reactions of electrons with some pyrimidine derivatives were investigated. The electrons, produced photolytically in alkaline glasses, were reacted with solutes to form anions. It was found that anions of thymidine and thymidine-5′-phosphate easily underwent proton transfer from surrounding water molecules to the $C_6$ position of the thymine ring. Anions of uracil and deoxycytidine did not undergo corresponding proton transfer reactions in the aqueous matrix at low temperatures. The role of electrons in the radiolysis of thymine-containing compounds including DNA was discussed. It was shown that electron reactions could account for the formation of the eight-lined ESR spectrum formed in the radiolysis of those compounds. (auth)

**20136** DNA SPECTROPHOTOMETRIC CHARACTERIZATION AFTER IN VIVO IRRADIATION. IV. THE DEOXYRIBONUCLEASE ACTION ON DNA EXTRACTED FROM NORMAL OR

IRRADIATED ANIMALS. Furnica, Maria (Oncologic Inst., Bucharest). Stud. Cercet. Biochim., 11: 261-8(1968). (In Rumanian).

The effect of deoxyribonuclease on the DNA from liver of rats x irradiated with whole-body doses of 300 or 900 R was evaluated. The results showed that DNA extracted from 900-R irradiated rat liver is more resistant to the denaturing action of pancreatic deoxyribonuclease (15% hyperchromic effect) as compared to the DNA extracted from normal liver (29% hyperchromic effect). AET administration did not protect the DNA against the modification which makes it resistant to deoxyribonuclease action. The irradiation effect appeared only when lethal doses were used and only at 10 days after irradiation. Cocarboxylase administered to rats irradiated with 900 R resulted in the appearance of a DNA resistant to deoxyribonuclease action 3 days after irradiation, or later. (BBB)

**20137** RADICAL FORMATION IN CYSTEAMINE FREE BASE AND CYSTAMINE·2HCl BY REACTION WITH ATOMIC HYDROGEN AND BY γ-IRRADIATION. Freyland, Werner; Mueller, Adolf (Kernforschungszentrum, Karlsruhe, Ger.). Int. J. Radiat. Biol., 14: 483-5(Dec. 1968).

Investigations were made on the mechanism of the radioprotective action of compounds. Radicals of cysteamine and cystamine·2HCl were produced by γ irradiation and by interaction with atomic hydrogen and their electron spin resonance spectra were compared. The electron spin resonance spectra following uv irradiation were also recorded. (F.M.M.)

**20138** ACTION OF ELASTIC NUCLEAR COLLISIONS ON INFECTIOUS DNA OF BACTERIOPHAGE φX 174. Kuerzinger, K.; Jung, H. (Kernforschungszentrum, Karlsruhe, Ger.). Int. J. Radiat. Biol., 14: 493-5(Dec. 1968).

The effects of elastic nuclear collisions were investigated by irradiating infectious DNA of bacteriophage φX 174 with monoenergetic protons in the energy range of 0.8 to 50 keV. The surviving fraction of DNA was determined, and the mechanism of inactivation was discussed. (F.M.M.)

**20139** THE REPLICATIVE ORGANIZATION OF DNA IN POLYTENE CHROMOSOMES OF DROSOPHILA HYDEI. Mulder, M. P.; van Duijn, P.; Gloor, H. J. (Univ. of Leiden). Genetica, 39: 385-428(1968).

Salivary-gland nuclei of Drosophila hydei were pulse-labeled in vitro with $^{3}H$-thymidine and studied autoradiographically in squash preparations. The distribution of radioactive label over the length of the polytene chromosomes was discontinuous in most of the labeled nuclei; in some nuclei the pattern of incorporation was continuous. Comparison of the various labeling patterns of homologous chromosome regions in different nuclei showed that specific replicating units are replicated in a specific order. By combining autoradiography with cytophotometry of Feulgen-stained chromosomes, it was possible to correlate thymidine labeling of specific bands with their DNA content. The resulting data indicate that during the S-period many or perhaps all of the replicating units in a salivary-gland nucleus start DNA synthesis simultaneously but complete it at different times. Furthermore, the data support the hypothesis that the chromomere is a unit of replication or replicon. The DNA content of haploid chromomeres was found to be about $5 \times 10^{-4}$ pg for the largest bands in Drosophila hydei. From the results of $^{3}H$-thymidine autoradiography and Feulgen-cytophotometry on neuroblast and anlage nuclei it was concluded that during growth of the polytenic nucleus heterochromatin is for the most part excluded from duplication. The results of DNA measurements in interbands of polytene chromosomes do not agree with a multistrand structure for the haploid chromatid. A chromosome model is proposed which is in accordance with the reported results and with current views concerning the replicative organization of chromosomes. (auth)

**20140** CHANGES OF CALCIUM METABOLISM OF RATS DURING HYPOKINESIA. Egorov, B. B.; Lobachik, V. I.; Kleimenova, L. N. Kosm. Biol. Med., 3: 55-8(Jan.-Feb. 1969). (In Russian).

Using the radioisotope $^{45}Ca$, calcium metabolism of rats kept for 30 and 60 days in restrained conditions was analyzed. The investigations were done on the skeletal system of the animals. A significant decrease of $^{45}Ca$ incorporation into the bone tissue of restrained animals was noted. The maximum value was found in the epiphysial portion of the femur. The rate of $^{45}Ca$ excretion from the bone tissue of test animals was higher than that of controls. (auth)

**20141** COMPLEMENT CONSUMPTION BY PARAMECIUM CAUDATUM CULTURE IN NORMAL FRESH SERA AND ITS SIGNIFICANCE IN THE PROGNOSIS OF RADIATION SICKNESS IN RATS. Cabadaj, S.; Praslicka, M.; Bernasovskii, I.; Chlebovska, K. (Safarik Univ., Kosice, Czech.). Int. J. Radiat. Biol., 14: 469-81(Dec. 1968).

Cultures of protista Paramecium caudatum grown on wheat medium consumed complement in normal fresh rat sera. This reaction was used as the criterion of damage in rats subjected to whole-body irradiation. The results were expressed as the number of minimum haemolytic doses (NMHD) of the complement fixed in the presence of the Paramecium culture. The higher the NMHD the more intense the reaction and vice versa. NMHD values showed considerable individual differences. They decreased, however, after lethal or sub-lethal x irradiation. High NMHD values in rats examined shortly before or after irradiation indicated a more favorable prognosis in survival than low values of NMHD. (auth)

## Ecology

*Refer also to abstracts 20226 and 20227.*

**20142** (COO-1156-30) RADIOECOLOGY OF SOME NATURAL ORGANISMS AND SYSTEMS IN COLORADO. Seventh Annual Progress, January 1, 1968-December 31, 1968. Whicker, F. W.; Dahl, A. H. (Colorado State Univ., Fort Collins. Dept. of Radiology and Radiation Biology). Feb. 1, 1969. Contract AT(11-1)-1156. 83p. Dep. CFSTI.

Project activities and accomplishments during the calendar year 1968 are reported. Work on the metabolism of $^{131}I$ in captive mule deer was essentially completed, and a condensed account is given. Retention, distribution, and skeleton-antler transfer of $^{85}Sr$ in captive deer and fallout $^{90}Sr$ accumulation in fetal deer were studied. Tissues of wild deer were assayed for $^{131}I$ and $^{137}Cs$. The results imply long range trends in $^{137}Cs$ levels and $^{131}I$ contamination in apparent response to Nevada Test Site activities. Trout and other samples from 20 montane and alpine lakes were assayed for $^{137}Cs$. Data are examined in relation to numerous ecological factors. Bone from trout was assayed for $^{90}Sr$ and these results are also given. Considerable progress has been made on $^{134}Cs$ kinetics in lake components and on retention of the nuclide in trout of various sizes held under different environmental conditions. Development of an outdoor pika colony was accomplished and 50/30 experiments on animals in captivity and in their natural mountain habitat were conducted. An LD 50/30 study was also completed on captive Richardson ground squirrels. Installation of facilities for the grassland radiation study was nearly completed. Preliminary vegetational surveys were made and sampling techniques evaluated. (C.O.)

**20143** (COO-1499-3) STUDIES ON ZINC IN FRESHWATER ECOSYSTEMS. Final Report. Kormondy, Edward J. (Oberlin Coll., Ohio). Jan. 1969. Contract AT(11-1)-1499. 32p. Dep. CFSTI.

Investigations were conducted on stable and radioactive zinc with regard to their fate and role in aquatic insects, their fate and role in aquatic plants, and their distribution in fresh-water ecosystems. Uptake and loss of $^{65}Zn$ were determined in the following species of Odonata: Tetragoneuria cynosura, Erythemis simplicicollis, Libellula luctuosa, Epicordulia princeps, Tramea lacerata, Ischnura verticalis, and Enallagma signatum. Seven day uptake studies with Libellula, Erythemis, and Tetragoneuria revealed that after 48 hrs, unit counts existed within the same range as in the 48 and 72 hr uptake studies. However, after this initial uptake there was a tendency for the total radioactivity to decline during the four last days of exposure to the tagged solution. After 48 hrs, Tetragoneuria, Erythemis, Libellula, Epicordulia, and Tramea each lost up to 50% of the total radioactivity accumulated. It was during the initial period that the loss rate was greatest; subsequently the rate decreased such that a level 25% of the maximum was not observed until after six days. Temperature studies with Tetragoneuria indicated that this species required about 24 hrs longer to reach the 50% loss level at 50°F and 40°F than at 70°F. Plastic aquaria containing 1000 ml of pond water were constructed for studies on volume. Microcosm studies were conducted to simulate conditions that might be met if $^{65}Zn$ were introduced into a natural environment. Results indicated that most of the isotope was accumulated by the plant material in the microcosm. Studies on the effects of the chelating agent, EDTA, on uptake and loss in Tetragoneuria and Erythemis showed a marked decline in total accumulation in both species. (H.L.W.)

**20144** (COO-1795-1) EFFECTS OF LIMNOLOGICAL FACTORS ON UPTAKE OF $^{137}Cs$ FALLOUT BY FISH. A Technical Progress Report, June 1968-March 1969. Kevern, Niles R. (Michigan State Univ., East Lansing). 11p. Dep. CFSTI.

Objectives of the study were to determine the influence of selected water quality parameters on the accumulation of $^{137}Cs$ by fish, to determine the influence of trophic position on accumu-

lation of $^{137}Cs$ by living components of the aquatic environment, and to facilitate the prediction of maximum concentrations of $^{137}Cs$ in food fishes when estimated inputs of $^{137}Cs$ to the environment are given. Tables and graphs are presented to show results of limnological analyses of five lakes and $^{137}Cs$ content of bass. Results of $^{137}Cs$ analyses of bass showed an inverse relationship with the conductivity of water. Improvements in methods included development of a better electrofishing system and an exchange column for practical field concentration of cesium in large masses of water. (H.L.W.)

**20145** (ORNL-TM-2466) PROGRESS REPORT IN POST-ATTACK ECOLOGY. Interim Progress Report. Auerbach, S. I. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 63p. Dep. CFSTI.

Separate abstracts were prepared for four sections of this report. A list of 28 references is included. (H.L.W.)

*For abstracts of individual sections see: 20083, 20328, 20329, and 20420.*

**20146** RESEARCH ON THE METABOLISM OF SOME RADIOACTIVE ELEMENTS IN THE MARINE ENVIRONMENT. Bernhard, M. (EURATOM-CNEN, Fiascherino, Italy). Rev. Int. Oceanogr. Med., 11: 11-59(1968).

From 3rd International Conference on Medical Oceanography, Nice, France. See CONF-670977.

Data available on the uptake, accumulation, and loss of radioactive and stable isotopes by marine organisms which are of interest to marine radiocontamination are reviewed. Among the various factors which influence the uptake and loss mechanisms special consideration is given to the concentration of the stable element and to the physico-chemical state of the stable and of the radioactive isotope in seawater. From the data available on the distribution of stable and radioactive isotopes under experimental and under natural environmental conditions the question is discussed, if a given isotope is taken up to a higher degree directly from the surrounding seawater medium or through the food-chain. In the light of the findings the merits of the two presently most widely used approaches (concentration factor and specific activity) for the prediction of the concentration of radioisotopes in marine organisms are discussed. (auth)

## Genetics and Cytogenetics

*Refer also to abstracts 20079 and 20323.*

**20147** (BNL-50058, pp 17-55) MUTATION-PROOF AND MUTATION-PRONE MODES OF SURVIVAL IN DERIVATIVES OF ESCHERICHIA COLI B DIFFERING IN SENSITIVITY TO ULTRAVIOLET LIGHT. Witkin, Evelyn M. (State Univ. of New York, Brooklyn. Downstate Medical Center).

Eight classes of strains, representing all possible combinations of $Fil^+$ and $Fil^-$, $Hcr^+$ and $Hcr^-$, and $Exr^+$ and $Exr^-$ phenotypes were isolated, by selection of successive mutations, from E. coli $B_{s1}$ ($Fil^+$ $Hcr^-$ $Exr^-$) and $B_{s2}$ ($Fil^+$ $Hcr^+$ $Exr^-$). These strains were compared to determine the separate and combined effects of each of the three pairs of genetic differences on uv radiosensitivity and on susceptibility to uv-initiated mutagenesis. Conclusions reached were as follows: The Hcr phenotype did not affect the ability of the strain to cope with unexcised uv damage nor the mechanism whereby it does so. The exr ($B_{s1}$) and exr ($B_{s2}$) mutations altered the mechanism whereby viable DNA is produced from DNA containing unexcised uv damage. Any $Fil^+$ strain and its $Fil^-$ counterpart were equal in their ability to effect excision repair, and in the efficiency and accuracy of the mechanism whereby they produced viable DNA from DNA containing unexcised uv damage. Also, uv survival curves and the concept of critical time and the mutagenic effects of nitrosoguanidine on these phenotypes were discussed. (C.O.)

**20148** (BNL-50058, pp 98-110) THE EFFECT OF EXOGENOUS NUCLEOSIDES AND NUCLEOTIDES ON RECOVERY OF X-RAY-INDUCED CHROMOSOME BREAKS. Beatty, Alvin V. (Emory Univ., Atlanta, Ga. Dept. of Biology).

The effect of exogenous nucleosides and nucleotides of the bases adenine, guanine, cytosine, thymine, and uracil and the bases themselves on the percentage of chromosome aberrations in x-irradiated cells of Tradescantia paludosa was investigated. All experiments were carried out at 30°C and all radiations were given in a helium atmosphere at 50 R/min for 8 min for a total dose of 400 R. Results indicated that the repair process, an abnormal requirement of the cell, differed from synthesis associated with replication; synthesis associated with replication appeared to be a well ordered process. A restriction on thymidine production modified chromosome replication and an exogenous supplement of thymidine removed this effect. It was concluded that whatever the repair mechanism actually is, it seemed to differ from synthesis associated with replication. (C.O.)

**20149** (BNL-50058, pp 111-33) REPAIR AND RECOVERY AT CHROMOSOME AND CELLULAR LEVELS: SIMILARITIES AND DIFFERENCES. Evans, H. J. (Aberdeen Univ. (Scotland). Dept. of Genetics).

That genetic damage resulting in chromosome structural change is a major cause of radioinduced cell killing is reviewed. Experiments are described in which recovery from sublethal and chromosome damage was measured. Some of the results supported the idea of a causal relation between chromosome aberrations and lethality, but others did not. Topics included in the review and discussions were cell survival and chromosome damage in Tradescantia, chromosome damage in other plant species (Vicia faba and barley) exposed to fractionated x-ray doses, and cell survival and chromosome damage in human leukocytes and Hela cells. It was concluded that the end points of cell lethality and chromosome structural change were developments consequent to radiation exposure, perhaps far removed in time from the initial absorption of radiation energy. It seemed probable that many different sorts of damage contributed to both end points, and that these damages (some common to both end points) were subject to modification by more than one repair system. (C.O.)

**20150** (BNL-50058, pp 179-89) REPAIR MECHANISMS IN RADIATION MUTATION INDUCTION IN THE MOUSE. Russell, W. L. (Oak Ridge National Lab., Tenn.).

Earlier work that showed a dose-rate effect on radioinduced specific-locus mutations in mice suggested that repair mechanisms operated against the induction of point mutations. New data supporting this conclusion are presented. A large x-ray dose given to female mice either singly or in two fractions yielded the same mutation frequency. This indicated that the mutations were not 2-hit in nature, and supported the view that the bulk of the dose-rate effect was not a phenomenon depending on 2-hit aberrations, but was due to the damage or saturation, at high dose rates, of a repair process that was effective at low dose rates. Evidence that the repair process could be effective at high dose rates too, provided the dose was low enough, is presented from two experiments, one using a small dose and the other a series of small doses. Further possible evidence for a repair mechanism came from the great reduction in mutation frequency observed in later matings of females exposed to either neutron or x irradiation. (C.O.)

**20151** GENETIC TRANSMISSION OF RADIATION EFFECTS ON THE MATERNAL OVARIES TO THE FILIAL GENERATIONS. Revesz, E. (Anatomisches Institut, Bern). Rev. Suisse Zool., 75: 77-101(Apr. 1968). (In German).

Effects of a single dose of 100 to 200 R of x irradiation of the ovaries of mice on the offspring during three subsequent generations were studied. In 126 offspring of the irradiated mothers paired with nonirradiated males there were 7.8% malformations as compared to 3.3% growth disturbances in 122 offspring of normal animals. The litter sizes were normal. In the second generation the malformations increased and were more severe. The litter sizes were slightly below normal. In 234 descendents 16.6% had developmental defects of a lethal or essentially sublethal nature, as compared to 2.7% of 110 control animals. The numbers and severity of defects were related to repeated irradiation of the maternal parents with a dose of 300 R and their mating, in part to males who were progeny of irradiated mothers. In the third generation the litter sizes were almost normal, but the number of defects increased. In 231 offspring 22.5% had developmental defects, as compared to a frequency of 2.9% in 168 control embryos. The surviving second generation offspring of irradiated mothers were considerably less resistant to common infections, showed delayed sexual maturation, frequently disturbed cycles, and somewhat premature senescence. This syndrome was particularly noticeable in animals with growth defects. (BBB)

**20152** A THEORETICAL STUDY OF MUTANT YIELD AND CELL KILLING AFTER TREATMENT OF HETEROGENEOUS CELL POPULATIONS. Oftedal, Per (Norsk Hydro's Inst. for Cancer Research, Montebello, Norway). Hereditas, 60: 177-210(1968).

In experiments on the genetic effects of low, acute x-ray doses (50 to 300 R) on Drosophila spermatogonia, a non-linear dose effect curve was found for the induction of sex-linked recessive lethals. While the overall increase in mutation rate was small, the highest yield was found after 150 R, giving a humped dose-effect curve. An interpretation of the findings was based on the assumption of heterogeneity in radiation sensitivity among the spermatogonia, and that the sensitivity to mutation induction and to cell killing was positively correlated in each cell. Calculations

are described for a model considering the mutagenic and cell killing effects of radiation on populations of heterogeneous sensitivities. Apart from inherent sensitivities, the most important aspect determining the dose-effect curve form is found to be the degree of coincidence in individual cells between the sensitivities to mutation induction and to cell killing. The model is discussed in relation to published experimental data from various materials. It was concluded that the humped dose-effect curve may be most economically explained by the assumption of two processes acting in opposition on a population of heterogeneous sensitivities. Experimental data from some organisms support the model as applied to radioinduced mutagenesis and cell killing. However, the general validity of the model has not been established, and more experimental data are needed. In particular, it is of interest to know if a humped dose-effect curve for mutation induction necessarily reflects a heterogeneity in survival, or, conversely, that a biphasic survival curve would of necessity imply a heterogeneity in genetic response. The model may be applicable to other cases where opposing processes are presumed to interact on cell populations, e.g., mutant yield being influenced by a repair system evoked by the treatment in question. The initial steep part would reflect the no-repair situation, and the high-dose straight part would reflect conditions under which maximally efficient repair operates. (BBB)

**20153** ISOLATION OF VARIANTS WITH INCREASED MUTABILITY FROM NEISSERIA MENINGITIDIS. Jyssum, Kaare; Jyssum, Sidsel (Univ. of Oslo). Acta Pathol. Microbiol. Scand., 74: 93-100(1968).

Whether variants with increased mutation rates following irradiation or chemical treatment appear in populations of Neisseria meningitidis with sufficient frequency to permit the isolation of a collection of mutator strains was studied. Genetic studies were performed with the following mutants obtained from the wild type strain M1 of Group B after uv irradiation or nitrous acid treatment of cells: M1-18 $his^-gly^-cp^+$, M1-8 $his^-arg^-cp^+$, M1-5 $his^-$ homoser$^-cp^+$, M1-48 $his^-cys^-cp^+$, M1-6 $his^-pro^-cp^+$. Genetic competence is indicated by the symbol $cp^+$ and incompetence that does not revert to competence by $cp^-$. The str-r marker was a single step high level resistant mutant. Among 56 strains of N. meningitidis that were scored for streptomycin-resistant organisms by the plate method, none was found that gave a high number of resistant colonies. These strains had no unusually high frequency of auxotrophic mutation. Characteristics of four variants with increased mutability are described. In the unstable variants pathways for biosynthesis of amino acids, vitamins, metabolism of sugars, and resistance to antibiotics were affected. The unstable variants contained mutator factors that could be transformed into mutator negative strains of N. meningitidis. (BBB)

**20154** RECOVERY OF COLONY-FORMING ABILITY AND GENETIC MARKER ACTIVITY BY UV-DAMAGED HEMOPHILUS INFLUENZAE. Day III, Rufus S. (Southwest Center for Advanced Studies, Dallas); Deering, R. A. Biophys. J., 8: 1119-30(Oct. 1968).

The rate of recovery of uv-irradiated H. influenzae from acriflavine-sensitized loss of colony-forming ability was studied at various acriflavine concentrations, uv doses, and temperatures. This rate (as calculated from an equation based upon certain assumptions) was on the order of 0.07/min/cell at 37°C. This did not vary greatly with uv dose or acriflavine concentration, but did with temperature, giving a $\Delta H^{\ddagger}$ of about 16 Kcal/mole. In another set of experiments, cells bearing 2 genetic markers (resistance to 2000 μg/ml streptomycin and to 2.5 μg/ml novobiocin) were irradiated and then incubated without acriflavine. Deoxyribonucleic acid extracts made from samples taken after various incubation times were assayed on antibiotic-sensitive cells using acriflavine to inhibit repair during and following transformation. Both in vivo irradiated markers were reactivated in the donor to the same extent (with a rate constant of 0.04/min). This result was in contrast to the results obtained when extracted DNA bearing the same markers was irradiated in vitro and used to transform cells. In this latter case the streptomycin marker was much more sensitive than the novobiocin marker. This difference is interpreted as being due to the mechanics of the transformation system. (BBB)

**20155** HERITABLE GLYCOGEN-STORAGE DEFICIENCY IN YEAST AND ITS INDUCTION BY ULTRAVIOLET LIGHT. Chester, V. E. (Arthur Guinness Son and Co., Dublin). J. Gen. Microbiol., 51: 49-56(Apr. 1968).

Cultures of several diploid strains of Saccharomyces cerevisiae were found to contain about 0.5% of glycogen-deficient cells. Ultraviolet irradiation increased the mutant frequency to about 5%, while 40% of the population survived. The mutants were detected by plating cultures on nutrient agar containing 1% glucose and staining 3-day colonies with iodine; normal colonies became brown due to the stored glycogen whereas the mutants remained white. The size of the mutant colonies was normal. Most of the mutants remained stable during subculture. Fractionation of the cellular carbohydrate confirmed that the mutant were deficient in glycogen. Glucose concentration in the growth medium had a marked influence on glycogen storage. When the mutants were grown on nutrient agar containing 8% glucose, glycogen was stored and the mutants could not be distinguished by iodine-staining from the wild type. Glycogen-deficient mutants contained higher than usual proportions of respiration-deficient cells. Respiration-deficient colonies, whether derived from glycogen-deficient or from normal cultures, contained appreciably less glycogen than those of the wild-type yeast. (BBB)

**20156** RADIATION-INDUCED POLYGENIC MUTATION IN ARABIDOPSIS THALIANA. I. SELECTION FOR FLOWERING TIME. Lawrence, C. W. (Atomic Energy Research Establishment, Wantage, Eng.). Heredity, 23: 321-37(Aug. 1968).

Selection was carried out on the basis of flowering time in populations of crucifer obtained by irradiating homozygous individuals, and selection lines were analyzed genetically by means of diallel crosses. Seeds from selected plants in one group of lines were re-irradiated with the same dose (90 KR) of $^{60}Co$ γ rays in the second, third, fourth, and fifth generations; those in a second group of lines were re-irradiated in the third and fifth generations only, while those in the last group of lines were not re-irradiated. In the second experiment single doses of either 30, 60, 90, or 120 KR were given to seeds in the first generation only. Selection response in the first, and probably also in the second, experiment was symmetrical and linearly related to dose, and the two sets of data gave similar estimates of the response per unit dose. The combined data gave estimates of the doubling dose lying between 12 and 28 KR, the lower value being the most likely. The average number of seeds per pod in plants derived from irradiated families was almost invariably lower than that in the control. In the early flowering lines the reduction in fertility is due to mutations independent of those influencing flowering, but pleiotropy cannot be ruled out in the late flowering lines. The results are compatible with the hypothesis that the properties of induced mutations depend on the genetic architecture of the character studied. (BBB)

**20157** CHROMOSOME DAMAGE IN X-RAY TECHNICIANS. Ebenezer, Lily N.; Sadasivan, G. (Osmania Medical Coll., Hyderabad, India). Indian J. Med. Res., 56: 1023-7(July 1968).

To investigate the chromosome damaging effects of low doses of radiation, chromosomes of technicians working in x-ray departments of several hospitals were studied. Analysis of leukocyte chromosomes showed a marked increase in incidence of breaks, together with gross changes in morphology. The incidence of aberrations varied from 20 to 50% as against their virtual absence in the control group. The presumption that x-ray technicians are sufficiently protected from harmful exposure, therefore, seems untenable. It is suggested that the small aberrations, at some future period in the life of the individual, may play a significant role in development of leukemias and other malignant conditions. This is discussed in relation to evidence from relevant literature. It is further felt that a 2-fold benefit would accrue from periodic chromosome analysis of this group of workers, namely, valuable data might be obtained regarding carcinogenic potential for humans of low doses of radiation (paucity of which exists); secondly, it might prove to be a more reliable method of evaluation of damage compared to the film badges. (BBB)

**20158** REFINED TEST FOR X-RAY INDUCED DOMINANT LETHALS IN DROSOPHILA. Wuergler, F. E.; Petermann, U.; Ulrich, H. (Swiss Federal Inst. of Tech., Zurich). Experientia, 24: 1293-4(Dec. 15, 1968).

A method for detecting x-radioinduced dominant lethal mutations in Drosophila following irradiation of eggs is described. A computer program and its applications to the data obtained are discussed. (C.O.)

**20159** STUDIES OF THE MUTATION INDUCTION BY THE INTERNAL RADIATION OF β-EMITTING RADIOISOTOPES IN CROP PLANT. 3. ON THE METHOD OF TREATMENT FOR GROWING PLANT. Onozawa, Yoshiro (Ibaraki Univ., Japan). Ibaraki Daigaku Nogakubu Gakujutsu Hokoku, No. 15, 7-15(Oct. 1967). (In Japanese).

Phosphorus-32 administration to rice by means of water culture gave good response to given doses and also excellent repeatability in the $^{32}P$ accumulation at reproductive organs. In this case, carrier-free condition was necessary for high efficiency of $^{32}P$ absorption. This method is difficult for large plants and large-scale experiments because of handling problems. Administration of radioisotopes (RI) through plant tops was applicable

not only for woody plants but also for annual plants such as cereals. In particular, the injection to the internode at various stages during reproductive growth of rice or barley seems to be quite reasonable because of its simplicity of handling and resulting relatively low individual variation of effects. The amounts of $^{35}S$ accumulated in the reproductive organs of rice varied according to the position where injection took place. But no such a position effect was found in case of $^{32}P$. In the experiments in which barley was treated by $^{35}S$ at meiotic stage and rice was treated by $^{32}P$ at pro-embryo stage, it was observed that amounts of RI incorporated in seeds which matured on the treated plants were almost proportional to the given doses. Biological effects of treatments, such as seed fertility and growth inhibition usually proportional to given doses. If treatment took place at later periods of growth, the seeds harvested from a treated plant each contained different amounts of RI. However, amounts of RI did not coincide with biological effects among these seeds. The experimental evidences suggested that the seeds which had been treated at earlier stages of embryonic development contained smaller amounts of RI than the seeds which had been more developed, but biological effects might be severe in the former seeds. (NSA of Japan) (TSS)

**20160** THE RESPECTIVE ROLES OF MITOTIC ACTIVITY AND OF CELL DIFFERENTIATION IN PLANARIAN REGENERATION. Chandebois, Rosine (Faculte des Sciences, Marseille). J. Embryol. Exp. Morphol., 20: 175-88(Sept. 1968).

X irradiation was used to inhibit mitosis in investigating the relative importance of mitotic activity and cellular differentiation in planarians. Experiments were performed on the freshwater planarians Dugesia gonocephala (and its asexual form D. subtentaculata) D. tigrina, D. lugubris, and Polycelis cornuta. In worms x-irradiated with a dose of 10,250 R, syncytium could always be observed until death occurred. As a blastema formed even when mitoses were blocked, the inhibition of regeneration could only be explained by its inability to produce differentiated tissues. The ability of D. subtentaculata to regenerate for about 10 days when it was sectioned immediately after irradiation, together with the complete lack of regeneration in worms cut 48 hr after irradiation, showed that it is not cell differentiation itself which is inhibited, but a preliminary mechanism which becomes blocked 48 hr after irradiation and which until then allows differentiation for about 10 days. It is suggested that blastema formation is not dependent upon the mitotic activity of the parenchyma since in planarians transected immediately after irradiation regeneration is possible in spite of the complete lack of mitoses. When planarians are cut some days later, however, regeneration fails, even in fragments whose mitotic activity is already restored (D. lugubris). Blastema formation is effected by elements already engaged in differentiation. It is always inhibited when differentiation becomes impossible; for instance, when the formation of cells of type I is stopped (by irradiation), when no wound healing occurs (histiotypic cultures), or when fusion of the dorsal and ventral edges of the cut does not occur. (BBB)

**20161** EFFECT OF PREMEIOTIC ULTRAVIOLET IRRADIATION IN SACCHAROMYCES. Takahashi, Toshiaki (Brewing Science Research Inst., Tokyo). Bull. Brew. Sci., 12: 15-33 (1966).

The effect of irradiation on diploid-strain Saccharomyces cerevisiae prior to sporulation, and the effect of uv-treatment on the offspring of uv-irradiants was studied. The survival rate of uv-irradiated vegetative diploid cells decreased considerably with the uv-dose, but their viability recovered markedly by the plating onto the sporulation medium. The irregular segregation of all genetic markers and the crossing over in the adjacent regions at a map length of about 5 to 25 units increased with the uv-treatment. But those increases were generally not parallel with the uv dose. The uv effects were removed by two back-crossings; but the effects were transmitted to the offspring of the uv-irradiants through sibmating. (NSA of Japan) (TSS)

**20162** RADIOSENSITIVITY OF EHRLICH ASCITES TUMOUR CELLS. I. VARIATION IN X-RAY SENSITIVITY DURING THE CELL-CYCLE. Lozzio, Carmen B. (Univ. of Tennessee, Knoxville). Int. J. Radiat. Biol., 14: 133-48(1968).

Non-synchronized cell populations of ELD ascites tumor cells were pulse-labeled and x-irradiated in vitro with 125 R, 250 R, and 500 R. The cells were grown in vivo in C3H/He Jax mice, and harvested at two hour intervals. Chromosome damage was scored at metaphase. Mitotic delay and cell survival were also studied in relation to chromosome aberrations. Pre-mitotic interphase death was not observed, whereas a significant decrease in cell number, related to the dose, was observed after irradiation, and $G_1$ was found to be the period most delayed. Chromatid aberrations were scored in unlabeled and labeled metaphases representing cells irradiated at different stages of S and $G_2$. The results clearly demonstrated that $G_2$ was the most sensitive period. Furthermore, cells irradiated during early and middle $G_2$ were more sensitive than those irradiated at late $G_2$; and cells from early S were more sensitive than those from late S. (auth)

**20163** THE X-RAYS INDUCED MUTATIONS IN ASPERGILLUS GIGANTEUS WEHM. MUT. ALBA ZURZ. Zurzycka, A. (Inst. of Plant Physiology, Krakow). Acta Soc. Bot. Pol., 36: 181-5 (1967).

Conidiophore elongation and carotenoid synthesis in Aspergillus giganteus mut. alba are affected by light. In order to study these phenomena three types of x-radioinduced mutants were isolated in which conidiophore elongation or carotenoid synthesis or both were different from the parent strain. Germinating spores were irradiated with doses up to 74 kR. The mutants were isolated from morphologically aberrant sectors among normal mycelia. (M.M.B.)

**20164** FACTORS THAT AFFECT THE RADIATION INDUCTION OF MUTATIONS IN THE MOUSE. Russell, William L. (Oak Ridge National Lab., Tenn.). An. Acad. Brasil. Cienc., 39: 65-75(Dec. 31, 1967).

A review is presented of research on genetics of mice at the Oak Ridge National Laboratory. Emphasis is placed on the specific gene locus method for testing the effects of physical and biological factors on the nature and frequency of radioinduced mutations in mice. The review is limited to those findings considered to be relevant to the estimation of genetic hazards of radiation for man. Rates of radioinduced mutations at seven gene loci tested varied more than thirty fold. There was a difference in distribution of induced rates of mutation in oocytes and in spermatogonia. From 90 R downward the mutation frequency in oocytes dropped rapidly from a value that was higher than that in spermatogonia to one that was much lower. While spermatogonia did not exhibit a threshold dose-rate for mutation induction, oocytes appeared to approach such a threshold at low doses. The comparative effects of fission neutrons, $\gamma$, and x radiation on oocytes and spermatogonia are discussed. The departure from a linear relation between mutation frequency and dose suggests that low doses of radiation do not pose the genetic hazards previously anticipated. Other topics reviewed are dose fractionation, radiation quality, and effects of the interval between irradiation and conception on mutation frequency. Investigations on the incorporation of $^{3}H$-uridine in oocytes suggest that the changing capacity for repair of genetic damage may be an important factor in the change in mutation frequency with time after irradiation. (M.M.B.)

**20165** PEROXIDE EFFECTS ON SURVIVAL AND MUTATION INDUCTION IN ULTRAVIOLET LIGHT EXPOSED AND PHOTOREACTIVATED BACTERIA. Doudney, C. O. (Albert Einstein Medical Center, Philadelphia). Mutat. Res., 6: 345-53(Nov.-Dec. 1968).

When uv-exposed cells of Escherichia coli strain B/r were incubated in hydrogen peroxide and yeast extract, a marked lethal effect was observed within 4 min. Previous photoreversal treatment (eliminating most pyrimidine dimers) did not reduce the amount of killing produced by the peroxide. Similar results were observed when the cells were incubated with yeast extract previously irradiated with uv. This effect was eliminated by the presence of the peroxide decomposing enzyme, catalase, during the uv-irradiation of the yeast extract. A slight lethal effect of peroxide-containing medium on unirradiated control cultures was seen. This was increased considerably if the cultures were exposed to photoreversing light prior to incubation with peroxide. The data suggest that some component both of the uv-light and (to a lesser extent) the white light from the photoreversing source induces some sublethal damage to the bacteria which renders them susceptible to the lethal effect of subsequent incubation with peroxide. The mutagenic effect of the peroxide was determined at concentrations which produce considerable killing (by utilization of induction of reversion to prototrophy in a $mfd^+$ and a $mfd^-$ double auxotrophic strain of E. coli). Incubation of unirradiated cultures in peroxide-containing medium caused no measurable modification of the mutation frequency. Incubation of the uv-exposed $mfd^+$ strain with peroxide resulted in an immediate and marked decline in mutation frequency which was not seen with the $mfd^-$ strain. No increase in mutation frequency of the $mfd^-$ strain was seen with incubation in peroxide suggesting that the lethal interaction of peroxide with the uv-damaged cell does not promote in surviving bacteria an increase in mutation frequency for this type of reversion to prototrophy. (auth)

**20166** HIGH TEMPERATURE DEPENDENCE OF LIQUID-HOLDING RECOVERY AS COMPARED WITH PHOTORECOVERY FROM UV-INDUCED DAMAGE IN SACCHAROMYCES CERE-

VISIAE. Ito, Takashi; Hieda, Kotaro (Tokyo Univ.). Mutat. Res., 6: 401-8(Nov.-Dec. 1968).

An attempt was made to determine the temperature dependence of the rate constant of liquid-holding recovery (LHR) from uv-induced mutation ($ad_1^+ \rightarrow ad_1^-$) and inactivation, using the diploid yeast Saccharomyces cerevisiae. Based on the finding that both recovery phenomena approximately followed first-order kinetics, the rate constant was defined as $k = -(1/t)\ln$ (recoverable fraction remaining/total recoverable fraction) where t is the holding time of the treated cells in non-nutrient liquid. The results may be summarized as follows: the temperature dependence of LHR for the mutation and inactivation was very similar over the experimental temperature range, 12 to 30°, suggesting the same limiting reaction may be involved in both cases; judging from the rather high value (about 6) of $Q_{10}$ as compared with the ordinary enzyme reactions in solution, the possibility was suggested that a major configurational change in the system might be required for the proper interaction between the repairing agent and the damage in LHR; photorecovery (PR) experiments carried out with the same system showed that the PR process had lower temperature dependence ($Q_{10} \simeq 4$) than LHR, as would be expected from the nature of the reaction. The value, however, seemed somewhat higher than the reported values in E. coli. The higher rate constant for mutation (0.098 $h^{-1}$ at 25°) than for inactivation (0.032 $h^{-1}$ at 27°) is discussed in relation to the dependence of recovery rate on the uv dose. (auth)

**20167** ACTION OF ULTRAVIOLET LIGHT ON THE GENETIC RECOMBINATION BY IRRADIATION OF PRIMORDIAL GERMINAL CELLS OF DROSOPHILA FEMALES. Proust, Jacqueline; Prudhommeau, Claude (Laboratoire de Biologie Generale, Orsay, France). Mutat. Res., 6: 419-26(Nov.-Dec. 1968). (In French).

An investigation was made on the uv-induced recombination in germinal cells of Drosophila melanogaster females. The Polar-Cap technique developed by Altenburg was used. About 2 hr subsequent to fertilization at 25°, pole cells appear close to the posterior surface of eggs, where they remain for approximately 70 min. In this position their nuclei can be reached by ultraviolet radiations, provided that eggs are dechorionated before the treatment. The following markers on the second chromosome were used: black (b), purple (pr), and engrailed (en). The dose of uv was 1000 erg/$mm^2$. The results indicate that the recombination frequencies are greater in the irradiated series than those observed in control series. No anomalies in the segregation pattern of each pair of genes could be detected in the irradiated series. In 7 out of 24 $F_1$ cultures a positive correlation with reference to increased recombination was observed between the markers b and pr and between pr and en. These findings suggest a meiotic effect of uv irradiations. (auth)

**20168** RECOMBINATION IN ULTRAVIOLET-SENSITIVE STRAINS OF SACCHAROMYCES CEREVISIAE. Snow, Richard (Univ. of California, Davis). Mutat. Res., 6: 409-18(Nov.-Dec. 1968).

Intergenic and intragenic recombination during vegetative growth and at meiosis was studied by selective plating techniques in diploid strains of yeast homozygous for alleles of six genes governing sensitivity to ultraviolet radiation. The following results were obtained: none of the uvs mutations caused a significant increase in spontaneous mitotic intragenic recombination; the frequency of intragenic mitotic recombination (gene conversion) induced by uv light was greater among survivors in the sensitive strains compared to wild-type controls, but was less when compared in terms of equal survival; and the dose-response curves for uv-induced mitotic recombination between the locus of a gene and its centromere were complex, but in most cases the uvs diploids showed a greater response than the controls. No differences from the controls were found in the frequency of intragenic or intergenic recombination at meiosis, but significant differences were found between certain uvs strains. (auth)

**20169** STUDIES ON THE INDUCTION OF TRANSLOCATIONS IN MOUSE SPERMATOGONIA. I. THE EFFECT OF DOSE-RATE. Searle, A. G.; Evans, E. P.; Ford, C. E.; West, B. J. (Medical Research Council, Harwell, Eng.). Mutat. Res., 6: 427-34(Nov.-Dec. 1968).

The effect of dose-rate on the induction of reciprocal translocations in mouse A type spermatogonia by 600 R x and γ irradiation was studied by scoring multivalent configurations in descendant spermatocytes. With x irradiation over a range of dose-rates from 0.8 to 913 R/min there was no significant change in the frequency of affected spermatocytes, which averaged 12.8%. With γ irradiation, however, there was a steady increase in frequency from 1.4% at 0.02 R/min to 12.1% at 86 R/min, the points fitting a straight line on a semi-log plot. At 0.08 R/min the x ray yield was twice that for γ rays. Possible reasons for these differences are discussed. Frequencies of 0, 1, 2 translocations per spermatocyte did not fit a Poisson distribution since there were less then expected in the 1-class, but more in higher classes. This was probably a consequence of differential radiosensitivity of the irradiated spermatogonia, although preferential clonal proliferation may also be involved. (auth)

**20170** ULTRAVIOLET ACTION SPECTRA IN PERSPECTIVE: WITH SPECIAL REFERENCE TO MUTATION. Giese, Arthur C. (Stanford Univ., Calif.). Contract AT(04-3)-326. Photochem. Photobiol., 8: 527-46(Dec. 1968).

Problems of determining action spectra are considered as well as various types of action spectra for uv action upon cell activities. Ultraviolet radiation is an effective mutagenic agent producing point mutations and chromosomal changes. It is readily absorbed by superficial layers of cells in tissues; therefore, special experimental procedures are necessary for induction of mutations in animals or plants. Ultraviolet radiation is, however, suitable for mutagenesis in microorganisms because the cells are small, permitting the radiation to reach the nuclei. Action spectrum studies reveal that uv mutagenesis results from absorption of the radiation by nucleic acid. The most prominent alteration in DNA following absorption of uv rays is dimerization of pyrimidines, chiefly thymine. Such a change not only retards DNA replication but results in errors (mutations). Ultraviolet radiation mutagenesis therefore depends upon the conditions before, during, and after irradiation. Thus immediate post-treatment with visible and long uv light splits pyrimidine dimers, thereby reversing impending uv mutagenesis. For cells kept in the dark, conditions which prevent DNA replication by interfering with the metabolism of the cell provide time for dark repair of the DNA lesion and so for reversal of the impending mutation. (auth)

**20171** RELATION BETWEEN REPAIR OF RADIATION DAMAGE AND MUTATION INDUCTION. Kimball, R. F. (Oak Ridge National Lab., Tenn.). Photochem. Photobiol., 8: 515-20 (Dec. 1968).

The development of the concept of repair of premutational damage at both the biological and molecular levels is reviewed. The important but not exclusive role that repair processes play in determining the mutation yield is stressed with emphasis on mutations induced by ultraviolet radiation. It is pointed out that under special circumstances repair may be sufficiently efficient to almost completely eliminate premutational damage. (auth)

**20172** GENETIC AND CYTOGENETIC EFFECTS OF THE NEUTRON IRRADIATION OF DURUM WHEAT. Scarascia-Mugnozza, G. T. pp 22-6 of Neutron Irradiation of Seeds, Vienna, International Atomic Energy Agency, 1967. (RT/BIO-(68)7).

Seeds of Triticum durum were treated with thermal neutrons in the Brookhaven National Laboratory reactor at a flux of $5.8 \times 10^8$ n/$cm^2$/s and with fast neutrons in the Stockholm University reactor. The differences in chlorophyll mutations induced by the two types of neutrons and between neutrons and x rays were reported. A comparison was also made of the mutation frequencies induced by chemicals and neutrons. (F.M.M.)

**20173** BIOCHEMICAL ASPECTS OF A GENETICALLY DETERMINED VARIEGATION IN ARABIDOPSIS. Redei, G. P. (Univ. of Missouri, Columbia). Contract AT(11-1)-1609. Genetics, 56: 431-43(July 1967). (COO-1609-2).

Seeds of Arabidopsis thaliana were x-irradiated with a dose of 10,000 R. A recessive mutant 1M was produced which in homozygous condition displayed variegation. To determine the role of the 1M locus, chemical analyses were made on the phosphorus, calcium and magnesium content of the mutant and wild type, and the activities of phosphatase, phosphomonoesterase, phosphodiesterase, and ribonuclease were measured. (F.M.M.)

## Health Physics and Safety

*Refer also to abstracts 19915, 19920, 19921, 19960, 20107, 20108, 20144, 20157, 20278, 20402, 20414, 20415, 20420, 20975, 20976, 20978, and 21063.*

**20174** (ANL-Trans-717) PROBLEM OF THE RADIATION LOAD BY INCORPORATION. Koenig, L. A. Translated by Elmar K. Wilip (Argonne National Lab., Ill.), from Atompraxis, 14: 467-70(1968). 12p. Dep. CFSTI.

Results of calculations for a number of radionuclides, which are of a particular interest in radiological protection, of the radiation load at the incorporation of 1.0 μCi and of the maximum permissible loading of the critical organ with nuclide are presented. (B.G.D.)

**20175** (BNWL-778-10) ENVIRONMENTAL SURVEILLANCE IN THE VICINITY OF HANFORD FOR OCTOBER 1968. Wooldridge, C. B. (ed.) (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Dec. 30, 1968. Contract AT(45-1)-1830. 17p. Dep. CFSTI.

The concentrations of most radionuclides in the Hanford environment during October, 1968, were at or below comparable 1967 values. The average shoreline exposure rate as measured at Ringold during October was 100 $\mu$R hr, somewhat higher than usual. The transport rate of $^{46}$Sc, one of the major contributors to shoreline exposure rates, has been included and will be reported routinely. (auth)

**20176** (CEA-CONF-1168) PERMEABILITY OF FABRICS IN CONTACT WITH TRITIUM AND TRITIATED WATER. Billard, Francois; Charamathieu, Andre; Morel, Paul (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). [1968]. 29p. (In French). (CONF-681013-9). Dep.

From 1st European Congress on Radiation Protection and Exhibition on Equipment Using Low Energy and Short Range Radiation Dosimetry, Menton, France.

By measurement of the activities of tritium in two ionization chambers separated by a membrane and by use of the results from a modified Barrer method, it was possible to classify fabrics by decreasing permeability to tritium and tritiated water in the manufacture of protective clothing or gloves for glove boxes and to select the best of the fabrics. But only one order of magnitude of the coefficients of permeability, diffusion, and solubility could be obtained. In order to determine with precision their value, it appears necessary to reduce the evaporation duration of the tritiated water injected and to regulate the temperature of the two chambers. (tr-auth)

**20177** (CEA-R-3655) MASS ATTENUATION AND MASS ENERGY ABSORPTION COEFFICIENTS FOR 10 keV TO 10 MeV PHOTONS. Joffre, Henri; Pages, Lucien (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Dec. 1968. 59p. (In French). Dep.

Mass attenuation coefficients and mass energy absorption coefficients for some elements and mixtures necessary for the study of tissue equivalent materials are given for photons in the energy range 10 keV to 10 MeV. After short definitions of the two coefficients, a compilation of these coefficients as a function of energy is given for simple elements, for certain mineral compounds, organic compounds, gases and particularly for soft tissues. (auth)

**20178** (CONF-680507) RADIOLOGICAL PROTECTION OF THE PUBLIC IN A NUCLEAR MASS DISASTER. Proceedings of a Symposium [held at] Interlaken, Switzerland, 26 May-1 June 1968. Brunner, H.; Pretre, S. (eds.) (Fachverband fuer Strahlenschutz e. V.). 688p. (In Several Languages). $10.00.

Separate abstracts were prepared for 54 papers presented at this symposium. Various aspects of the consequences of nuclear explosions are considered. (H.L.W.)

*For abstracts of individual papers see: 19863, 19864, 19919, 19920, 19929-19933, 20005-20011, 20179-20213, 20265, 20266, and 20344.*

**20179** (CONF-680507-, pp 25-8) PLANNING FOR DECISION MAKING IN A NUCLEAR DISASTER. Taylor, Lauriston S. (National Academy of Sciences, Washington, D. C.).

Planning for ways and means to recover from a major disaster is a difficult and seemingly unrewarding task at best. Almost by its very nature, the form and magnitude of disaster is unpredictable—otherwise it would not be allowed to occur. This is even more true in the eventuality of a nuclear attack, where again, by its very nature, its form is carefully concealed by its perpetrator. At the same time it is in recognition of this fact, that any advance thinking about, or planning for, a disaster is far better than none at all. Furthermore, it must be recognized that planning against any credible type of disaster, within man's imagination, while perhaps not focusing on the situation that might actually occur, will nevertheless by its very process have developed a degree of orderly thinking about the problem and the development of cadres of individuals who will be better equipped to improvise when the necessity arises. While the best answers for a particular problem may not be developed either beforehand or at the time of crises, the development of such thinking will serve to help make decisions as what not to do. If you know some things not to do, your decision process may be simplified just through the elimination of unproductive alternatives. Clear recognition of the kinds of problem that may have to be faced after a nuclear attack will serve to focus attention on those which are amenable, or are not amenable to a reasonable solution. One aim of the Conference is to identify as many of these problem areas as possible. (auth)

**20180** (CONF-680507-, pp 32-5) DEVELOPMENTS SINCE THE 1963 WHO SEMINAR IN GENEVA. Russell, R. Scott (Agricultural Research Council, Wantage (England). Radiobiological Lab.).

The developments which have occurred in the area of radiological protection since the Seminar on the Protection of the Public in the Event of Radiation Accidents in Geneva in 1963 are briefly reviewed. The most significant development is in the re-evaluation of basic aspects of radiological protection such as maximum permissible levels, limiting the amount of exposure, and remedial measures to take in case of radiation emergencies. (B.G.D.)

**20181** (CONF-680507-, pp 36-8) PALOMARES TWO YEARS AFTER. Rodriguez, Eduardo Ramos (Junta de Energia Nuclear, Madrid (Spain)).

A review is presented of the problems associated with radiological protection after the Palomares accident. The problems included fallout; fragment dispersion; contamination of animals, plants, and soils; decontamination of houses and other property; and psychological factors. (B.G.D.)

**20182** (CONF-680507-, pp 39-45) A PRELIMINARY REPORT ON THE B-52 ACCIDENT IN GREENLAND ON JANUARY 21, 1968. Koch, Joergen (Copenhagen Univ. (Denmark). H. C. Oersted Institut).

A brief survey of the administrative and radiological aspects related to the B-52 accident in Greenland is presented. The clean-up operation, which was undertaken to prevent endangering the population in the area to radiation hazards, is briefly described. (B.G.D.)

**20183** (CONF-680507-, pp 93-104) LOCAL FALLOUT HAZARD ASSESSMENT. Miller, Carl F. (URS Corp., Burlingame, Calif.).

The systematic assessment of hazards due to local fallout from single or multiple nuclear events is usually done by means of mathematical models and electronic computers. The program may include models of the device, fallout formation, fallout distribution, exposure dose, plant uptake, foliar contamination, assimilation, beta dose, diets, and other processes to describe the movement of fallout and the radionuclides in the biosphere and the coincident radiation doses to biological species. The application of these models in studies has shown that the external gamma hazard is the predominating hazard to man and most animals. The contact beta and beta bath dose to plants, small animals, and insects is important but difficult to assess because the models and response data are not complete. The internal hazards, except for a few rare circumstances, are generally of minor importance. The results indicate that serious ecological consequences, possibly only on a localized basis, generally would have a low probability of occurrence, especially for the important man-controlled ecosystems. (auth)

**20184** (CONF-680507-, pp 105-17) BETA RADIATION HAZARDS AND BETA-GAMMA RELATIONSHIPS ASSOCIATED WITH LOCAL FALLOUT. Teresi, J. D. (Naval Radiological Defense Lab., San Francisco, Calif.).

A discussion of the beta hazards and beta-gamma relationships is presented in which the effects of beta sources in contact with the skin are emphasized and related to the associated gamma exposures. Literature is cited to show that the dose required for early recognizable transepidermal injury is approximately constant at 1400 ± 300 rads even though the accompanying surface doses may vary widely. Reports are cited that present the exposure to fallout beta radiation and cathode rays required to cause severe skin burns including a summary table of a description of biological effects of beta radiation on the skin (immediate, delayed, persistent changes and long term) and a table summarizing the estimated doses required to produce certain acute effects on the skin (ranging from 0-600 rads resulting in no acute effects to 30,000-100,000 rads resulting in skin blistering in less than one day). Also cited are reports of studies on the effects of very high doses to small areas of the skin the results of which indicate that the effect from individual small particle sources should be less than that expected from distributed sources delivering the same dose at the base of the epidermis. A condensation is presented of previously published estimates of the contact beta doses associated with gamma radiation measurements of nuclear weapon fallout. The calculations made in these early reports were for early fallout from nominal-yield weapons based both on experimentally determined beta-to-gamma ratios and on a combination of experimental measurements of beta dose rates to the skin of animals from $^{32}$P plaques and the calculated gamma exposure rates

expected from contaminated smooth circular planes of various sizes. A condensation of recent computations of the beta doses due to fallout radiation for nuclear weapon yields of 1, 10, and 100 MT for a tissue depth of 0.003 centimeters at various air gaps separating the tissue surface from the contaminated surfaces is included. (auth)

**20185** (CONF-680507-, pp 165-9) WHAT TYPES OF MEASUREMENTS ARE NEEDED? Cook, C. Sharp (Naval Radiological Defense Lab., San Francisco, Calif.).

A discussion regarding some typical physical situations for which instruments are needed to measure the radiations associated with the problem postulated for this symposium is presented. Included in these suggested observations are the exposure and exposure rate of the gamma-radiation field produced by a distributed fallout source, and the level of contamination of various objects within the area in which local fallout occurs. Other measurements are required to determine the amount of radioactivity that has been adsorbed by plant life in the area, or has sunk into the ground to be later brought into the plants through their root systems. Unless proper measurement of contamination is made, such contamination may lead to the transfer of radioactivity over a rather large area if the transport of food occurs over such an area. Finally, measurements other than those associated with nuclear radiations from fallout must sometimes be made in an emergency situation. Even though such measurements are not necessarily a part of the subject-matter for this symposium, people should at least be aware that measurement of physical parameters in addition to those produced by the fallout radioactivity may be needed. (auth)

**20186** (CONF-680507-, pp 170-4) DOSE PROBLEMS AND POSSIBILITIES FOLLOWING A NUCLEAR CATASTROPHE. Kiefer, Hans (Kernforschungszentrum, Karlsruhe (West Germany). Schule fuer Kerntechnik). (In German).

The measurement problems are illustrated on five problem areas as they would occur in a nuclear catastrophe. These are (1) analysis of the radiation composition by type, energy, and intensity in order to determine the radiation damage and the origin of the catastrophe; (2) observation of the site and chronological distribution of the radiation level; (3) observation of the possible specific consequences (for example, by ground water contamination or through the biocycle by milk or meat consumption); (4) establishment of the dose burden of the population involved; and (5) radiation protection of the auxiliary medical personnel. These problems are closely connected since a dose estimation of the population can not be made with the individual possible deviations when the radiation level and its distribution is not known; the radiation composition must be analyzed and the possible incorporation methods (by respiration, drinking water, or directly or indirectly through the biocycle) must be considered. Also the radiation protection of the auxiliary personnel is related to the results of the radiation analysis. The measurement expense varies greatly from one problem area to the other and depends on the state of restoration operations. First only the measurements of the site dose distribution and the radiation analysis is necessary in order to give meaningful instructions to the population. Later the control of the chronological dose pattern and investigations on possible incorporation sources become necessary. The radiation protection must be proportional in its scope to the number of personnel affected. (tr-auth)

**20187** (CONF-680507-, pp 175-86) PERSONNEL DOSIMETRY IN LARGE-SCALE NUCLEAR EMERGENCIES. Becker, K. (Oak Ridge National Lab., Tenn.).

Basic considerations concerning mass-scale personnel dosimetry of the civilian population and/or armed forces are briefly discussed. These considerations include the general desirability of such a system, versatility, and accuracy requirements, the evaluation of the dose information, the importance of dose modifying factors, and problems of organization. It is concluded that, for tactical weapons, a photon and neutron dosimeter which measures the initial radiation is desirable. For large yield weapons, a dosimeter for the photons, and possibly also for the beta radiation from fallout may be sufficient. The main advantages and limitations of different systems, which have recently been developed, are compared. In particular, individual use, or optimized combinations of luminescence (glass and TLD) systems for gamma/beta measurements, silicon diodes for neutron detection, and dose-rate independent ionometric devices (Semirad) are suitable for supplying useful information for immediate medical treatment and the estimation of possible late somatic or genetic radiation damage. Other techniques which are still under investigation may permit further improvements. The evaluation of the personnel doses of the survivors of Hiroshima and Nagasaki by the ORNL Dosimetry Research Section is also briefly described. With considerable efforts, including the simulation of the actual exposure conditions using an unshielded reactor operated on a tower at up to 500 m altitude, it has been possible to determine the individual neutron and gamma doses of almost all survivors within approximately ±10%. (auth)

**20188** (CONF-680507-, pp 202-6) CONSTRUCTION AND EQUIPMENT OF SOME MEASUREMENT TRUCKS AND MOBILE LABORATORIES FOR RADIATION PROTECTION MEASUREMENTS IN THE COUNTRYSIDE. Stremme, W.; Engelhardt, S.; Mueller, S. (Frieseke und Hoepfner G.m.b.H., Erlangen-Bruck (West Germany)). (In German).

Measurement vehicles fulfill in contaminated country many tasks with respect to the establishment of the desirability and accessibility of roads and streets and on the determination of possible residence times for persons. It must (1) demarcate the contaminated country by measurement of the dose output, and determine the activity concentration in the air, on the ground, and in the surface water; (2) prepare and measure samples brought from the contaminated area; and (3) determine the external and internal contamination of persons. In order to fulfil task (1), a 1.5 to 2 ton panel truck manned with two to three persons is suitable. Protective clothing and masks are necessary. The truck will be equipped with a dose output meter with a recorder, detector installation for the location of radiation sources; air dust collector; mobile ratemeter for orientating determination of the surface contamination; and device for taking, storage, and processing of samples. For the second task a 5 to 7 ton trailer is necessary with work places for at least 4 persons. The inside room is shelter ventilated so that the work can be carried out in low-degree contaminated areas. The work is divided into one section for the processing of samples and a measurement section. The measurement devices will handle $\alpha$, $\beta$, and $\gamma$ radiation. One or two multichannel pulse height analyzers are necessary for spectrometric determinations. The devices should be as simple as possible, but with automatic recording. The mobile laboratory should not be sent into highly contaminated country. (tr-auth)

**20189** (CONF-680507-, pp 207-11) SOME CONSIDERATIONS OF THE USE OF A HELICOPTER FOR AERIAL RADIOLOGIC PROSPECTING. Osipenco, A. (Centre d'Etude de l'Energie Nucleaire, Mol (Belgium)). (In French).

In spite of very severe precautions which are the rule in the nuclear domain, it is impossible to neglect the probability of occurrence of an accident in which the importance and extent of its consequences can vary within wide limits. In each nuclear organization the services responsible for the safety often can define the possible accidental situations and prepare methods and means of meeting them. In the case of nuclear accidents of some importance or of nuclear war which causes the dispersion of radioactive material in the environment one of the first major concerns is the determination of the extent of the zones contaminated and the approximate level of contamination. The most rapid means of attaining this end with the least delay and with sufficient precision seems to be in aerial radiological measurements. At the Mol CEN, because of the importance of dairy products in this part of the country, emphasis was placed on the demarcation of zones contaminated with $^{131}I$. In effect, this isotope is characterized not only by a high radiotoxicity but by a relative difficulty in retaining it in appropriate filters. The first results of the study were communicated at the Colloque de Saclay in November, 1963. The more recent developments and the results of the control measurements made systematically with the purpose of knowing the background in the vicinity of these installations were reported. It appeared desirable to extend the method to the detection of other substances and particularly to any mixture of fission products. A first step, theoretically and practically, was devoted to the search for an isolated source: the calculation methods and the experimental results obtained with two types of devices are given. The calculations allowing the predetermination of the spectral evolution and the radiation rate with the altitude are reported. The results obtained with the measurement of a mixture of fission products after variable decay times are also given. A discussion is presented of the respective merits of various detectors and a review of the difficulties in the application of the methods proposed. (tr-auth)

**20190** (CONF-680507-, pp 279-306) DIETARY CONTAMINATION: ITS SIGNIFICANCE IN AN EMERGENCY. Russell, R. Scott (Agricultural Research Council, Wantage (England). Radiobiological Lab.).

Following a nuclear catastrophe the isotopes $^{137}Cs$, $^{131}I$, $^{89}Sr$, and $^{90}Sr$ are considered to be the critical ones with regard to dietary contamination. The discussion is limited to agricultural

produce. The transfer of finely divided, freely soluble fission products through food chains is discussed. The importance of milk as the foodstuff most extensively and rapidly contaminated with $^{131}I$ and $^{89,90}Sr$ is emphasized. Studies on radiation doses from world-wide fallout indicate that the total radiation environment of the population is much smaller than expected. Dietary contamination occurring after reactor accidents is discussed. The external gamma dose from fission products deposited as fallout is discussed in relation to deposit of the critical nuclides. The importance of particle size and solubility in determining the extent to which radioactivity will enter food chains is discussed. An appendix is included to show data on the relationship between the deposition of $^{131}I$, $^{137}Cs$, $^{89}Sr$, and $^{90}Sr$ in finely divided freely soluble form and internal dose to the population owing to dietary contamination. (H.L.W.)

**20191** (CONF-680507–, pp 307-14) PRINCIPLES AND HYPOTHESES FOR THE INTERPRETATION OF RADIOACTIVE CONTAMINATION IN A NUCLEAR MASS DISASTER. Striebel, H. R. (Basel Univ. (Switzerland). Dept. of Physics).

The interpretation of radiation measurements after the deposit of radioactive fallout is part of the critical examination of an emergency and therefore an important base of all forthcoming counteractions. Logically and sequentially the interpretation is framed by the acquisition and presentation of the data on one side and by the weighing and selection of the appropriate action on the other side. This fact allows to dovetail measurements, interpretations and decisions, but includes the risk that, because of the influence of preconceived notions, the range of measurements is biassed and therefore the view of the situation distorted. To aim at the decision while taking and interpreting measurements may save a lot of time and is, therefore, in view of a timely decision of prime importance, when the radioactive fall-out is young, i.e., rapidly changing. In later phases, however, an image of the contamination as complete and objective as possible should be searched for, and this implies many measurements which presumably will not influence the final decision. The number and type of measurements and the way of interpretation as well as the weighing and selection of the proper actions thus depend on the age of the radioactive fallout. In an acute or short-dated contamination a timely decision requires the limitation of measurements to a very small number, if possible according to a preconceived scheme. By making use of working hypotheses, the data are then evaluated with respect to the chances of survival and the freedom of action only. Working hypotheses are the results of experience (test explosions, etc.) and calculations and permit to obtain a quick and rounded-off image of the situation on the basis of few but selected measurements. This image, of course, bears the uncertainty of the hypotheses it is based on. As the fall-out settles and the contamination approaches a quasi-stationary state the working hypotheses need to be examined and replaced by accurate measurements. These problems will be discussed in detail on hand of an example. Since the time elapsing between the process of making the decisions and their impact on the situation are many hours or even days, the interpretation of the data must be an extrapolation to the time, when the measures should come into action. This is the more important the faster the contamination changes. Extrapolations are based on sequences of measurements and/or on assumptions on the time-behaviour of the fall-out and contamination. They should never be extended over longer periods than half the time during which the development of the actual situation has been observed by measurements. Some methods of extrapolation and prediction will be illustrated with a second example. (auth)

**20192** (CONF-680507–, pp 333-9) RADIOLOGICAL DATA PROCESSING IN AUSTRALIAN CIVIL DEFENCE. Posener, D. W.; Symmons, H. F. (Commonwealth Directorate of Civil Defence, Canberra (Australia)).

An outline is given of Australian radiological processing procedures, during periods of early fallout. From the real-time readings provided by a fixed instrumental network, reduction gives the important parameters required by decision-makers (arrival time, cessation time, and activity level), with early indication of developing areas of most serious hazard. The procedures are simple and economic. (auth)

**20193** (CONF-680507–, pp 340-5) THREE-DIMENSIONAL SCHEME FOR CLASSIFICATION OF RADIOACTIVITY MEASUREMENTS IN THE BIOSPHERE. Winiger, P.; Huber, O.; Halter, J. (Fribourg Univ. (Switzerland). Physikalisches Institut). (In German).

A system is developed to classify measurements of the gross $\beta$-activity and of particular isotopes in the air, precipitation, the soil, and the vegetation, as well as the resulting concentration of the isotopes in important foodstuffs and in the human body. The system is formulated by a three-dimensional matrix. The first index denotes the medium of the biosphere, the second the object of measurement in the medium, especially the isotope of interest, and the third the applied reference of mass. Every element of the matrix consists of the time dependent functions for the collection stations. The correlation coefficients between two media are represented by a second three-dimensional matrix. By means of this system the measurements of the radioactivity in Switzerland during 1961-1966 can be evaluated and compared with corresponding foreign information. In an emergency situation this system may be used to collect and to classify the actual measurements. (auth)

**20194** (CONF-680507–, pp 346-61) ESTIMATION OF A LEVEL-GUIDE APPLICABLE TO THE POPULATION IN CASE OF INHALATION OR INGESTION FOLLOWING A NUCLEAR CATASTROPHE. de Maere, X. (Centre d'Etude de l'Energie Nucleaire, Mol (Belgium)). (In French).

The studies made on the consequences of a nuclear or thermonuclear conflict evaluate the destructive effects due to shock waves, incendiary and burn effects due to thermal waves, and the radiation rate following the initial radiations or local radioactive fallout. The numbers cited are so eloquent on this point that it can be asked if a study of the biological effects of radioactive fallout by contamination of the food chain or of the ambient air represents any interest for the civilian or military authorities because of the amplitude and urgency of the decisions to be taken following the primary effects of the explosion. The response appears positive if, complementarily to preventive and corrective measures taken to combat the primary effects, the following are also considered: the necessity of using rapidly and as well as possible in the contaminated zones (or the immediate proximity) the available human potential for the operations of rescue, restoration, retaliation, or defense; the existence of low-power tactical atomic bombs; the interest for the civilian or military commander of having available objective elements permitting him to take, in spite of the general disorganization, decisions imposed on him without making mistakes of several orders of magnitude in the evaluation of risks. The purpose of the present study is then to define succinctly some aspects of the problems connected with the contamination of the environment by early or late fallout and to present a mathematical model permitting the calculation of level-guides applicable to the population in the case of ingestion or inhalation of specific isotopes or isotopic mixtures. As biological effects associated with irradiations of an acute character can be determined in the evaluation of the situation, not only the integrated dose in the case of prolonged incorporation of radioisotopes must be considered, but also the maximum dose rate delivered during a limited period must be taken into account. The durations of inhalation periods are taken equal to one hour, six hours, 12 hours, one day, and 10 days; those relative to ingestion are one day, two days, a week, two weeks, and the entire life. Some application examples are given concerning the amplitude and the nature of the risks associated with particular types of situations and their time evolution. (tr-auth)

**20195** (CONF-680507–, pp 362-75) GRAPHIC REPRESENTATION FOR RAPID ESTIMATION OF EXPECTED DOSE IN EXPOSURE TO CONTAMINATION. Halter, J.; Huber, O.; Winiger, P.; Fe, V. (Fribourg Univ. (Switzerland). Physikalisches Institut). (In German).

After radioactive contamination a rapid evaluation of the consequences is of great importance. In the first place, the poisoning of the environmental air can be measured; in this step the dose, which man would receive from the various radiation sources, can be assumed to an order of magnitude. All additional measurements, as in fallout or land contamination, improve the approximation in progressive independence on the original assumption on the transition from one medium to the other. For the external irradiation it was assumed that a normal mixture of $^{238}U$ fission products fulfills homogeneously the upper half-space ($z > 0$), whereas man is found at the coordinate origin $x = y = z = 0$. The calculated dose outputs per $pCi/m^3$ and $\mu Ci/cm^3$ air are represented as a function of the age of the mixture in a diagram. Analogous diagrams were also prepared for the dose output per deposited activity on the ground ($rad/hr/mCi/km^2$ and $rad/hr/\mu Ci/cm^2$) with and without penetration (deposition with precipitation and dry deposition). The integral external dose up to $t = \infty$ by activity deposited on the ground is represented in the form of nomograms with the deposition time as a parameter. The internal total dose to be expected, originating from the air, for the whole body, the lungs, and the critical organs (varying with the age of the mixture) was carried out as a nomogram. The case of contaminated drinking water was also analyzed. Additional nomograms concern the combined effect of external plus internal total doses integrated up to $t = \infty$, dose with contamination of the environmental air, and the dose from external plus internal irradiation from the environmental air plus the external irradia-

tion from deposited activity. In all graphic representations, the assumed time for the arrival of the fission products extends from 1 hour up to 30 weeks after the occurrence. Doses received from contaminated foods were not considered. It was shown how calculations could be made in a practically occurring case. The variable or unvariable parameters determined were critically considered. These include the type of fission material, induced activities, fractionation of the fission product, duration of the air contamination, structure of the earth and penetration of the precipitation, and transition from near-by precipitation to tropospheric precipitation. (tr-auth)

**20196** (CONF-680507–, pp 376-83) RADIATION RISKS FROM DIFFERENT INTERNAL AND EXTERNAL SOURCES AFTER LOCAL FALLOUT. Helander, E.; Miettinen, J. K. (Helsinki Univ. (Finland). Dept. of Radiochemistry).

Civil defence authorities have to make decisions within hours or days and give instructions, not only on the residence time in civil defence shelters, but also on the utilization of surface water for drinking and the consumption of vegetables, milk, eggs, etc., after local fallout. The importance of different food items has been studied by several authors, but the situation tends to be complicated, as the contribution of different sources to the radiation dose varies with time and distance. An attempt is made to compare the radiation doses from different sources as a function of fission yield, time, and distance on the basis of the idealized fallout pattern from 1 MT fission yield burst at 15 m.p.h. wind speed (presented in The Effects of Nuclear Weapons by Samuel Glasstone). The results are presented in the form of a simple tabulation which enables one to make rough comparisons of different sources of the radiation risk at the conditions specified in the study. (auth)

**20197** (CONF-680507–, pp 387-92) CHEMICAL RADIATION PROTECTION. Langendorff, Hanns (Freiburg Univ. (West Germany). Radiologisches Institut). (In German).

In nuclear disasters and catastrophes the protection precautions sufficient for normal cases are unable to guarantee man and his biological environment satisfactory protection. It is therefore necessary to seek additional agents and methods to reduce the danger from energetic radiation. In recent times it has been shown that it is possible to increase the radiation resistance in higher organisms by the administration of certain chemicals. The experiments and data available in this area are still relatively slight to transfer them to man. It can be acknowledged however that the administration of materials of a given chemical nature such as thiol compounds and biogenic amines will be considered one day as supplementary protection precautions. (tr-auth)

**20198** (CONF-680507–, pp 398-418) PROTECTIVE AND REMEDIAL MEASURES TAKEN FOLLOWING THREE INCIDENTS OF FALLOUT. Dunning, Gordon M. (Atomic Energy Commission, Washington, D. C.).

The stated topic of this symposium is, "We want to discuss the radiation protection measures after a nuclear mass disaster by which large areas have become so severely contaminated with radioactive material that it constitutes a major hazard for the public." Fortunately it is not possible to document directly this topic because such an event has never occurred. We are forced then to look for other situations that may provide relevant information and guidance to our discussions. There were three incidents that occurred following atmospheric nuclear weapons test detonations and, although they have been reported previously, bear recounting for they do show, (a) what decisions were made and on what bases, (b) the manner in which the decisions were carried out, and (c) the results of the protective actions taken. There was a relatively heavy fallout on the Marshall Islands in the Pacific following an atomic test detonation on March 1, 1954 that required the evacuation of 239 inhabitants. There was also a situation in 1953 when, as a precautionary measure, about 4500 persons in St. George, Utah were asked to remain indoors for a period of two hours and in 1962 countermeasures were instituted by local and state health authorities in Salt Lake City in the state of Utah to reduce the levels of iodine 131 in the milk consumed by the public. The Pacific incident in 1954 illustrates the necessity of, and benefits to be derived from, good safety plans that are fully implemented. The St. George, Utah incident in 1953 shows the favorable results from a program of education of local officials and the public and the close cooperation with the local authorities. The Salt Lake City, Utah incident in 1962 demonstrates the need for radiation protection guides that are closely understood by all concerned and the necessity to monitor directly for the type of data required (such as iodine 131 in milk) rather than attempt to predict by extrapolating and reinterpreting other kinds of data. (auth)

**20199** (CONF-680507–, pp 433-45) DECONTAMINATION AS A REMEDIAL MEASURE. Miller, Carl F. (URS Corp., Burlingame, Calif.).

The removal and disposal of local fallout particles by the usually available decontamination method has limited but specific usefulness as a remedial measure when utilized in conjunction with an effective fallout shelter system. Because of exposure dose constraints, decontamination operations must be conducted sometime after the fallout has been deposited and, therefore, its major application would be to gain an earlier recovery of vital facilities than would be possible by waiting for the radioactive decay to take place. Data on the effectiveness and efficiency of decontamination of roofs, paved areas, land areas, and other exposed surfaces by such methods as firehosing motorized flushing, motorized sweeping, scraping, grading, and bulldozing (as applicable) have been obtained. Methods have been developed for utilizing these data in the preparation of operational plans for the post-attack recovery of contaminated vital facilities and areas. (auth)

**20200** (CONF-680507–, pp 446-55) FIRST RESULTS FROM THE PROGRAMME OF ACTION FOLLOWING THE PALOMARES ACCIDENT. Iranzo, Emilio (Junta de Energia Nuclear, Madrid (Spain)).

The contamination to persons, soils, air, and vegetation following the Palomares accident is briefly discussed. The gross alpha activity was determined for estimating this contamination. (B.G.D.)

**20201** (CONF-680507–, pp 456-9) SOILS AND PLANTS AS INDICATORS OF THE EFFECTIVENESS OF A GROSS DECONTAMINATION PROCEDURE. Fowler, E. B.; Buchholz, J. R.; Christenson, C. W.; Adams, W. H. (Los Alamos Scientific Lab., N. Mex.); Rodrigues, Eduardo Ramos; Celma, Margarita; Iranzo, Emilio; Ramis, Conchita Alvarez (Junta de Energia Nuclear, Madrid (Spain). Division de Medicina y Protection).

The results of an investigation on the soils-plant relationship which was initiated to obtain data relative to plutonium concentrations in the soil and possible resulting concentrations of plutonium in the plants grown on those soils are presented. (B.G.D.)

**20202** (CONF-680507–, pp 460-70) TOWARDS INTERIM ACCEPTABLE SURFACE CONTAMINATION LEVELS FOR ENVIRONMENTAL $PuO_2$. Kathren, R. L. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.).

The physical and biological factors pertinent to the establishment of acceptable surface contamination levels for environmental $^{239}PuO_2$ are examined. A brief analysis of the surface contamination hazard from a serious accident involving the release of $^{239}Pu$ is presented. A bibliography of forty-nine references is included. (B.G.D.)

**20203** (CONF-680507–, pp 471-80) PROTECTIVE CLOTHING FOR RESERVE IN CASE OF A NUCLEAR CATASTROPHE. Suter, Fred (Eidgenoessisches Institut fuer Reaktorforschung, Wuerenlingen (Switzerland)). (In German).

In a nuclear catastrophe it is indispensable that both individuals as well as entire troops of a civil defense site must be available in the area contaminated by fallout in order to carry out measurements or other activities important for the population. The contamination protection of these persons represents an important problem which has often been unconsidered or underestimated. The protective clothing used and tested in atomic installations can not be used for this purpose without additional study although guidelines for the construction of such material can be obtained from the tests already made. For example, the use of ventilated plastic protective clothing is not suitable in the case of civil defense on purely technical grounds although these represent the best solution in the physiological respect. These ventilated clothings require air supplies and a current source for the air supply plant or portable relatively heavy compressed air containers with a limited air supply. Non-ventilated clothing can be used although with these there is a limitation on the length of service. The advantage is in the gas mask. This guarantees the air supply. The problem of the removal of the radioactive contaminated clothing is intimately connected for the clothing construction and the selection of the material. The clothing represents a first contamination problem for the wearer. These problems were studied. On the basis of studies made in atomic plants with highly radioactive contaminations, protective clothing types suitable for civil defense were designed. (tr-auth)

**20204** (CONF-680507–, pp 483-93) RADIOBIOLOGICAL INFORMATION NEEDS FOR DISASTER PLANNING. Taylor, Lauriston S. (National Academy of Sciences, Washington, D. C.).

Following a nuclear attack, one of the critical aspects for operations planning is to estimate the availability of useful manpower. To provide necessary personnel for recovery operations means must be provided to arrive at estimates of radiation exposure and injury in order to determine how long and at what radiation levels people may work. To provide this information a study of the build-up of radiation effects, both as a function of total dose and rate of delivery, was undertaken. (B.G.D.)

**20205** (CONF-680507–, pp 494-516) RE-EXAMINATION OF NCRP REPORT NO. 29. LeRoy, George V. (Metropolitan Hospital, Detroit, Mich.).

Report No. 29 is re-examined with respect to four topics: 1) the objectives of radiation protection in a war emergency; 2) 200R: the largest brief dose that does not cause illness severe enough to require medical care; 3) the problem of internal deposit of radionuclides; and 4) ERD, the dose-time relationship, and schemes for regulating exposure post-attack. The critique is conducted in relation to the appropriateness of certain value judgements, the interpretation of empirical clinical observations, and the results of contemporary radiobiological research. The opinions expressed are those of the author and are not the official position of the NCRP or the government of the United States. The author believes that it is probably not practical to attempt to regulate post-attack exposure on an age-sex basis designed to influence genetic injury. There does not appear to be any reason to select some other value than 200 R, or 132 rad, as a reasonable limit for a single or brief exposure in a war emergency. More attention should be devoted to countermeasures against radioisotopes of iodine and strontium in fallout. The conceptual basis of ERD is not compatible with current ideas about certain biological effects of radiation. Even thoug it may appear to be a feasible way to deal with the dose-time problem in civil defense operations, the ERD scheme should no longer be used. Other ways to handle the dose-time problem are discussed. (auth)

**20206** (CONF-680507–, pp 517-37) EMERGENCY RADIATION EXPOSURE CONTROL. Greene, Jack C. (Office of Civil Defense, Washington, D. C.).

To be realistic and effective, a plan or system for the control of a population's exposure to fallout radiation should: (a) Include exposure control both during and after the in-shelter period, and (b) consider both internal and external radiation emitters. The approach employed by a trained systems analyst will facilitate the development of such a system. The analyst should take into account all of the inherent subelements or components that comprise an effective system. These include shelter quality and stay time; mutual and improvised radiation shielding; remedial movement; decontamination (area, as well as food and water); thyroid blocking through the ingestion of stable iodine; and internal and external exposure criteria. Analysis of the devised system will provide an understanding of the value of various optical countermeasures under a variety of possible circumstances. It will also help define the interrelationships of the countermeasures and the seriousness of the constraints. As a next step, the total exposure control system should be considered and analyzed as a subelement or component of a broader system, i.e., the system for a community's post-attack reorganization and recovery. Such analysis will focus attention on the interrelationships between the exposure control system and other systems, such as food supply and medical supply and treatment. An outline is presented of a suggested systems approach to the development of a radiation exposure control plan; decision parameters and criteria involved in such development; suggestions on standardized nomenclature and terminology (lack of which has inhibited past efforts); and the results of other pertinent research effort.

**20207** (CONF-680507–, pp 556-64) EVALUATION OF SYSTEMS FOR NATIONAL SURVIVAL AND RECOVERY. FitzSimons Neal.

Probably the most difficult job of the systems evaluator is extracting from the decision-maker the specific objectives of the system. For example, vague statements about saving lives, protecting property, and facilitating recovery might be adequate for broad guidance on civil defense programs, but ultimately the questions of who, what, where, when and why must be answered. The more clearly they are answered with regard to any given system, the better the evaluation of it; and better evaluations should lead to better decisions. The problem is–there are so many who's and what's and where's ... that a method must be evolved to evaluate systems. The method proposed is, mnemonically (isolate-sort-sequence-sum)$^R$, where R indicates an iterative process. The first three processes, isolate, sort, and sequence, lead to the structuring of the system. Generally, the structure will be composed of nodes and links; the nodes representing major components (or decision points) of the idealized system, the links indicating nodal interactions. A system may be geographic, schematic or combinations of both, and in any case may be time-dependent. Once a system has been built, it is usually subjected to operational analysis (i.e., tested), although sometimes evaluations may be made once the "best" forms of the system are determined. Operational analysis attempts to show what happens when a system operates under various constraints and sometimes can indicate preferred options. Typical operations analysis techniques include use of algorisms for routing, allocating, queuing, etc. The sum of a given system is the net result of a given system test. A final evaluation may require the selection of the "best" configuration for a given system or the best alternative of several candidate systems–the difference is a matter of degree rather than kind; system improvement cf. system replacement. Most decision-makers are value-judgement oriented. It is the responsibility of the systems evaluator to present him with non-esoteric results in a form which is readily scrutinized, and has to prime decision factors, such as effectiveness, efficiency, cost, and ramifications clearly shown. (auth)

**20208** (CONF-680507–, pp 565-88) METHOD FOR DETERMINATION OF AN OPTIMUM PROTECTIVE SHELTER CONCEPT. Ginsburg, Theo (Eidgenoessische Technische Hochschule, Zurich (Switzerland). Laboratorium fuer Atmosphaerenphysik). (In German).

All investigations on the worth of protective precautions against nuclear warfare leads to the problem on how to use the available means to obtain an optimum protective effect. In order to derive valid data for these problems, a statistical method was suggested. This means that mathematical models of the population distribution and the general danger of the situation must be represented with which the attach and the losses occurring can be simulated. For this purpose a method was developed and a computer program was devised which make it possible to determine the loss probability for nuclear attack for agglomerations (agglomerations are areas in whose center there is a high density population which is surrounded by a region with low population density). The parameters determining the model are distributed as follows: demographic parameters (population distribution and displacement), attack parameters (caliber and type of beginning, scatter radius, casualty parameters), protection parameters (strength of the air raid shelter, cost per air raid shelter space), working diagrams and zero curves, concept parameters (space distribution of the air raid shelter), and organization parameters (completeness of the air raid shelter at the attack). Studies were made with the help of this program to obtain concrete suggestions for the protection concept to be selected. Two protection precautions were investigated: one a long-range program on the construction of air raid shelters and the other a short-term solution for the reducing of the concentration of the population in centers. (tr-auth)

**20209** (CONF-680507–, pp 589-607) VULNERABILITY OF FOOD TO NUCLEAR ATTACK. Bresee, J. C.; Griffin, S. A.; Shinn, A. F. (Oak Ridge National Lab., Tenn.).

Food is the most vital component of a post-attack recovery program. Its adequacy depends upon pre-attack stocks, the ratio of the vulnerability of food to that of the population, and the availability of emergency transportation. Trends in food stocks in the United States and problems involving potential maldistribution are discussed. Livestock as a food resource is described, and the results and implications of a recent survey of livestock protection factors are presented. (auth)

**20210** (CONF-680507–, pp 608-13) THE ORSEC RADIOLOGIC PLAN. Reine, Philippe (Centre National d'Etudes de la Protection Civile, Nainville-les-Roches (France)). (In French).

In order to relieve accidents and catastrophes occurring in the nuclear sector, an assistance organization system was set up in each department under the title ORSEC Radiological Plan. The general dispositions of the ORSEC radiological plan are analyzed. After a review of the general principles, some details are given on the command organization and the different persons composing it. A distinction is made between the alarm and the alert and the insecure zone and the control zone. Some applications were made on the general dispositions ordered in the base interministerial instruction, chiefly an interministerial instruction on the organization of the assistance in the case of accident occurring on public roads during the transport of radioactive substances. The manner in which the different operations should be implemented is defined. In France, up to the present, there have been only minor accidents, but the organization is prepared in case of serious accident or catastrophe. (tr-auth)

**20211** (CONF-680507–, pp 614-22) DEVELOPMENT OF RADIATION MEASUREMENT CREWS (MEASUREMENT EQUIPMENT). Tritremmel, Ch. (Oesterreichische Studiengesellschaft fuer Atomenergie G.m.b.H., Seibersdorf. Institut fuer Strahlenschutz). (In German).

Austria still has no civil defense law although endeavors for civil defense have been made by the government and private organizations. The principal emphasis is on teaching the public about the necessity for civil defense and the development of initial organizations for civil defense. The already existing organizations that can be expanded to provide for active civil defense are discussed.

The programs for the development of radiation civil defense technicians and military units are described. (J.S.R.)

**20212** (CONF-680507-, pp 623-8) RADIATION PROTECTION DESIGN IN BUILDINGS. Berne, Robert (Office of Civil Defense, Washington, D. C.).

The radiation protection requirements of future building design is discussed. The design requirements for normal functions are similar to those for fallout protection. The difference is in shielding requirements. The techniques used to meet these requirements are briefly described. Examples of radiation protection design considerations are presented. (B.G.D.)

**20213** (CONF-680507-, pp 629-38) PROJECT FOR AN UNDERGROUND ANTI-ATOMIC SHELTER. Combes, Rene (Societe d'Etudes Techniques et d'Entreprises Generales, Le Plessis-Robinson (France)). (In French).

The role of the antiatomic shelter is defined. An example is given of the evaluation of the radioactive danger following nuclear bomb explosion. A typical air raid shelter is described. The devices used for the radiation detection, control and systematic radiological monitoring are described. Some general ideas are presented on the design of antiatomic shelters. (tr-auth)

**20214** (HMI-B-78) NUCLEAR CHEMISTRY DIGEST. PART IV. FUNDAMENTALS OF RADIATION PROTECTION AND DOSIMETRY. Hacke, J. (Hahn-Meitner-Institut fuer Kernforschung, Berlin (West Germany)). Dec. 1968. 92p. (In German). Dep.

A handbook on the fundamental concepts of radiation protection and dosimetry is presented. The interaction of radiation with matter is described, and the dose concepts and units are given. The maximum permissible radiation burden for man is defined. The methods for the calculation and measurement of the dose output at particular locations in radiation fields are illustrated. Calculation of shielding is described. The dangers from incorporation of radionuclides are considered. (J.S.R.)

**20215** (MIT-952-5(Pt.1), pp 137-83) DOSIMETRY. (Massachusetts Inst. of Tech., Cambridge. Dept. of Physics).

Semi-empirical and theoretical relations for determining the energy loss of heavy charged particles in matter are compared. The determination of the dose rate of alpha particles to an inert layer overlaying a substance uniformly loaded with an alpha emitter is described. (B.G.D.)

**20216** (MIT-952-5(Pt.1). pp 184-99) GENERAL RADIOBIOLOGY. (Massachusetts Inst. of Tech., Cambridge. Dept. of Physics).

Data are presented on the content of $^{137}Cs$ as related to the content of $^{40}K$ in normal human subjects, measured by whole-body $\gamma$ counting during 1961 to 1968. Results showed a peak in $^{137}Cs$ body burdens during the fall of 1964 with a decrease by 1968. Results of measurements of $^{40}K$ activity were used to determine the effects of diet and exercise on the lean body mass of humans. Whole-body $\gamma$ counting was also used to measure the retention of $^{131}I$-labeled thyroxine during 25 days following intramuscular injection in a patient with no thyroid function. (C.H.)

**20217** (MIT-952-5(Pt.1), pp 315-409) URANIUM MINE DOSIMETRY AND RADIATION CONTROL. (Massachusetts Inst. of Tech., Cambridge. Dept. of Physics).

A discussion of radiation dosimetry and control in uranium mines is presented. Topics include a personal alpha monitor for measuring exposure to inhaled radon daughter products, techniques for mine ventilation, tracer for marking flow in leaching holes, theoretical growth and decay of the short-lived daughter products of radon as deposited on filters, accuracy of the Kusnetz method for estimating working level values in mine atmospheres, instrumentation for in-mine, instant measuring of working level alpha radon concentrations, and basic concepts in uranium mine ventilation. An engineers' guide is also presented on the elementary behavior of radon daughters or some basic principles concerning radioactive transformations, radon daughter product working levels, the accumulation of activity in filters, and the summation rules. (B.G.D.)

**20218** (NP-17805) OPERATIONS PLAN FOR OFF-SITE SURVEILLANCE FOR THE LAUNCH OF A SNAP-19. (Public Health Service, Las Vegas, Nev. Southwestern Radiological Health Lab.). May 10, 1968. 20p.

The responsibilities and detailed procedures for off-site monitoring by the Southwestern Radiological Health Laboratory during the launch of SNAP-19 from Vandenberg AFB, California are discussed. Topics included are selected sample control and analytical procedures, determination of gross alpha activity in sea water and natural water samples, estimation of deposited alpha activity on soil, vegetation, and similar sample types, estimation of deposited alpha activity on Flora, radioassay procedures, and general field procedures. (B.G.D.)

**20219** (ORNL-CD-6) INDEXES TO 708 UNCLASSIFIED DOCUMENTS ON CIVIL DEFENSE. Levey, Joanne S.; Klein, Ann S.; Clark, Ann (comps.) (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 231p. Dep. CFSTI.

A list of 708 unclassified unlimited-distribution documents from the Civil Defense Research Library is presented. Also, key word, corporate author, report number, and author indexes are given. (W.H.K.)

**20220** (ORNL-TM-2539) TRITIUM LOSS FROM TRITIUM SELF-LUMINOUS AIRCRAFT EXIT SIGNS. Niemeyer, R. G. (Oak Ridge National Lab., Tenn.). Mar. 25, 1969. 12p. Dep. CFSTI.

A study of tritium loss from self-luminous aircraft exit signs during certain normal and abnormal conditions is described. The amount of tritium oxide was determined in each case since the biological effect of the oxide is much greater than that of elemental tritium. It was found that ~2% of the tritium in the light sources was in the form of tritium oxide. Of the total tritium released from a broken exit sign, ~99% occurred during the first 1.75 hr. It was concluded that the permeation rate of tritium through the glass tubes is so low as to be inconsequential from a safety standpoint. (auth)

**20221** (SWRHL-38r) OFF-SITE SURVEILLANCE ACTIVITIES OF THE SOUTHWESTERN RADIOLOGICAL HEALTH LABORATORY FROM JULY THROUGH DECEMBER 1966. (Public Health Service, Las Vegas, Nev. Southwestern Radiological Health Lab.). Dec. 1968. 20p. Dep. CFSTI.

The Southwestern Radiological Health Laboratory of the Public Health Service performed off-site radiological surveillance for ten announced events during the period from July through December 1966. This surveillance is conducted in the public areas surrounding the Nevada Test Site under a Memorandum of Understanding with the U. S. Atomic Energy Commission. No reactor experiments were conducted during this time. During the six-months period there was one event, Derringer, conducted on September 12, 1966, which released radioactive effluent that was detected only in an unpopulated location off the Nevada Test Site. Also during this period an underground test, Project Sterling, was conducted in Mississippi on December 3, 1966 as part of the Vela Uniform program. No radioactivity attributable to this detonation was detected in the off-site area. Analysis of all sampling and surveillance performed during the six-month period indicates that the safety criteria established by the Atomic Energy Commission for the off-site population were not exceeded. (auth)

**20222** SWEEP X RADIATION FROM COLOR TELEVISION SETS. Kolb, W. (Physikalisch-Technische Bundesanstalt, Brunswick). Bull. Ass. Suisse Elec., 59: 95-6(Feb. 3, 1968). (In German).

Dose rates of x radiation from commercial television sets and color picture tubes were measured. As compared to black and white sets, color tubes operate at higher voltages and emit 25-KV x rays which are absorbed less in the picture tube and ballast tube, and increase quadratically with the tube voltage. In all of the sets tested the dose rates at the surface of the chassis were less than 0.1 R/hr. The dose rates decreased linearly with distance, and at a distance of 1 m the dose rate was 10 $\mu$R/hr. The dose rate of 3 $\mu$R/hr at the usual viewing distance of 3.5 m was less than the environmental dose rate from building materials of 5 to 20 $\mu$R/hr. Assuming a daily viewing period of 3 hr, the annual dose would be ~3 mR. This is ~2% of the average population radiation burden in Germany which amounts to 150 mR. Although other high-voltage tubes, such as ballast tubes can produce x radiation, the amount that can be detected outside of the receiver housing depends on tube construction and location in the set. (BBB)

**20223** STUDIES ON INTEGRAL DOSE AND RELATIVE TUMOR DOSE IN TUMOR THERAPY. PART I. DIFFERENT METHODS OF IRRADIATION IN A TYPICAL CASE OF BRONCHIAL CARCINOMA. Eichhorn, Hans-Juergen; Richter, Juergen; Welker, Klaus; Lessel, Almuth; Matschke, Siegfried (Institut fuer Krebsforschung, Berlin). Strahlentherapie, 136: 547-53 (Nov. 1968). (In German).

The total integral dose and relative total tumor dose were calculated for five different treatment modalities for bronchial carcinomas, for tumors of typical size and position within a normal thorax. It was shown that for a minimal equal tumor dose, the integral dose of the five tumors varied between 11 and 16%, and the total integral dose had variations of 30%. It was possible in this way to eliminate up to 33% of unnecessary radiation dose for an equal tumor dose. (auth)

**20224** THE SIGNIFICANCE OF $^{137}Cs$ IN MAN AND HIS DIET. Gustafson, Philip F.; Miller, James E. (Atomic Energy Commission, Washington, D. C.). Health Phys., 16: 167-83(Feb. 1969).

Diet and whole body measurements of $^{137}Cs$ from 1961 through 1967 were presented for laboratory and university personnel. The differences in $^{137}Cs$ whole body burden across the United States were less than suggested by variations in regional $^{137}Cs$ fallout levels, and variations from one regional group to another were no greater than variations observed within a group from a specific location. This pattern was attributed to a common source of staple items such as grain products and meats. The biological half life of $^{137}Cs$ in adults ranges from 50 to 150 days. This is sufficiently short that equilibrium, or near equilibrium, between diet and body burden is established, even when the dietary level of $^{137}Cs$ changes fairly rapidly. The mean body burden of $^{137}Cs$ in the U. S. population was presented, and the radiation exposure due to this burden was calculated. The concentration effect observed from diet to man was discussed, together with the radiological importance of a possible long-term $^{137}Cs$ reservoir in bone. A prediction of future levels of $^{137}Cs$ in man and his diet for several different circumstances is given. (UK)

**20225** CALCULATION OF INTEGRAL DOSE IN $^{60}Co$ RADIATION. Richter, Juergen (Institut fuer Krebsforschung, Berlin). Strahlentherapie, 136: 544-6(Nov. 1968). (In German).

An equation for calculation of the integral dose with a maximal error of 8% is presented. Using electronic computers, one could also calculate easily and rapidly the integral dose for treatment with fixed fields, moving beams and with wedge filters. (auth)

**20226** INTERNATIONAL REVIEW OF MEDICAL OCEANOGRAPHY, 3rd INTERNATIONAL CONFERENCE ON MEDICAL OCEANOGRAPHY, 19–21 SEPTEMBER 1967, NICE, FRANCE. Rev. Int. Oceanogr. Med., 11: 1-221(1968). (In French and English). (CONF-670977).

Five separate abstracts from this conference were prepared for inclusion in NSA. Other papers covered sodium metabolism in a crab, $^{65}Zn$ turnover in early development of sea urchins, iron movement in sea waters, research in medical oceanography, ocean pollution problems (including economic and legal aspects), and bacteriological problems. (C.O.)

*For abstracts of individual papers see: 20106–20108, 20146, and 20227.*

**20227** STUDIES ON THE CONCEPT OF CONCENTRATION FACTOR BETWEEN MARINE ORGANISMS AND WATER WITH REGARD TO INTERPRETATION OF LIMITS. Bittel, R.; Lacourly, G. (EURATOM–CEA, Fontenay-aux-Roses, France). Rev. Int. Oceanogr. Med., 11: 107-28(1968). (In French).

From 3rd International Conference on Medical Oceanography, Nice, France. See CONF-670977.

The determination of the concentration factors (F) existing between sea organisms and water gives an idea of the intensity of the transfer of radioactive contamination in the ecological aquatic chain. If seafood is directly consumed by man, the F value permits theoretical estimation of the limits of radioactivity of water. Values for F also permit establishment of a list of organisms which may be considered as biological indicators for the contamination of the hydrobiological systems. Bibliographic research shows that, for the same species or group of species and for the same radionuclide, the concentration values vary, often between very wide limits. This is because of an important variability of measurement conditions. A single value for F is therefore insufficient. To evaluate radioactive contamination of a marine site, therefore, one must select constants in relation to the radioecology, and data must be accompanied by information on many factors to be valid in comparisons. (C.O.)

**20228** MEASUREMENTS OF URETERAL RADIATION DOSES IN GYNECOLOGIC CANCER PATIENTS. Laakso, Leo; Groenroos, Matti; Vilhonen, Erkki (Turku Univ., Finland). Strahlentherapie, 136: 562-5(Nov. 1968).

The LiF dosimeter was used for the measurement of ureteral radiation doses in gynecologic cancer patients. Nineteen measurements of ureteral radiation doses were made with LiF teflon microrods in connection with radium therapy administered to 14 patients. The rods, five to 15 in number, were placed in a ureteral catheter. The radiation load to the ureters grew when the radiation doses increased; on the other hand, the amount of radiation to the ureters diminished when the distance from the source of radiation lengthened. However, there were considerable variations between the different series, probably associated with topographic-anatomic variations of the ureter and uterus, and tissue reactions. (auth)

**20229** SIMPLE DETERMINATION OF FACTORS FOR CHARACTERIZING RELATIVE TUMOR DOSE IN $^{60}Co$ IRRADIATION. Welker, Klaus (Institut fuer Krebsforschung, Berlin). Strahlentherapie, 136: 554-6(Nov. 1968). (In German).

A method is described for rapid and approximative determination of the integral dose and the relative total tumor dose. The calculation was derived from a planar dose, determined by a planimeter from the isodose drawing on the treatment plan. An example was presented and compared with results obtained by other methods. (auth)

**20230** THERMOLUMINESCENT DOSIMETRY OF $^{90}Sr$-APPLICATORS FOR HYPOPHYSIS IMPLANTATION AND RADIATION PROTECTION MEASUREMENTS DURING INTERSTITIAL IRRADIATION OF THE HYPOPHYSIS. Ruden, Bengt-Inge; Notter, Gustaf; Sundbom, Lennart; Melander, Olof (Karolinska Institutet, Stockholm). Strahlentherapie, 136: 537-43(Nov. 1968). (In German).

The dose intensity and distribution of two $^{90}Sr$ applicators for interstitial therapy of the pituitary gland was measured with LiF-teflon rods. A small asymmetry and difference in dose rate was shown for the two applicators. Radiation personnel dosimetry revealed a relatively high dose at the fingers of the operator during the application. The causes and proposals for reduction of the dose were discussed. Intra-hypophyseal measurements confirmed earlier calculations and measurements of the dose in phantoms. (auth)

**20231** HANDLING $PuO_2$ OUTSIDE GLOVEBOXES. Carroll, R. M.; Robertson, H. E. (Oak Ridge National Lab., Tenn.). Nucl. Appl., 6: 7(Jan. 1969).

The use of a protective coating of naphthalene on a $(Pu,U)O_2$ specimen is described. No detectable contamination was released from the specimen during handling outside of a glovebox. The naphthalene was easy to apply and remove. (M.M.B.)

**20232** RADIATION PROTECTIVE CLOTHS. Takizawa, Shozo (to Shigematsu Works Co., Ltd.). Japanese Patent 1968-21280. Sept. 6, 1968. Filed Oct. 15, 1965.

The head, with an all-around transparent part, is fixed to the coat made of a dust and gas proof cloth. Gloves are attached to the opening end of sleeves; the base part of gloves is inserted between two sheets made at the sleeve end. A communication-purpose terminal and an exhaust valve are installed onto the coat. The trousers are also made of the same material as the coat; likewise, heavy socks are attached to the opening end of the trousers. The coat and the trousers are connected by a belt. An air-supply tube runs to the belt and it then branches into two small tubes; one tube goes into the head via a silencer, and the other under the coat and trousers, being further branched there. (NSA of Japan)

**20233** THE PROTECTION OF THE EYE BALLS IN LINEAR ACCELERATOR X-RAY TREATMENT OF THE HYPOPHYSIS: A HOLLOW-OUT RADIATION TECHNIQUE. Ueda, Toshio; Kitabatake, Takashi (Aichi Cancer Center Hospital, Japan). Nippon Igaku Hoshasen Gakkai Zasshi, 28: 1002-9(Oct. 1968). (In Japanese).

The selective protection of the eye balls in rotational radiation treatment of the hypophysis applied with linear accelerator is investigated and the effects of different size of protectors and field sizes on dose distribution in 6 MeV were studied. The magnitude of dose reduction at the center of tumor with the radius of protector was estimated and measured. The dose at the center of rotation is as follows

$$D_h = D_r \times \frac{360 - 8\theta}{360} + e^{-\overline{\mu\phi}} \frac{8\theta}{360}$$

where $D_h$ = dose at the center of rotation in the hollow-out technique
$D_r$ = dose at the center of simple rotation technique
$e^{-\overline{\mu\phi}}$ = average absorption value of lead protector
$\theta$ = the angle of radiation shadow

The estimated value in the equation was approximately equaled that measured with Siemens condenser r-meter. The deviation of the measured Tissue-Air-Ratio has ±1.25% accuracy at the level of the estimated value. (NSA of Japan)

**20234** NORMALIZATION OF FIELD SIZES AND DOSE INTENSITIES FOR THE SIEMENS 42 MeV BETATRON. Rassow, Juergen (Ruhr Univ., Essen). Strahlentherapie, 136: 426-36 (Oct. 1968). (In German).

A normalization allowed an exact and comprehensive deduction of the dose-intensity $\dot{D}$ for photons and electrons of all energies between 5 and 43 MeV, for all field sizes and filters. Measurement

of one reference value permitted calculation of the absolute values. Up to energies of 30 MeV the dose rate of the beam followed closely the relation $\dot{D} \sim E^n$. The exponent n had a value of 2.8 for photons without filter and decreased to 2.27 for fields of increasing surfaces. The value of n for electrons depended on the scatter foil and was between 1.24 and 2.37. The half-value angle $\alpha_{\frac{1}{2}}$, where the dose intensity was half the intensity at axis, followed a simple correlation to be established between dose rate, the homogeneity wanted and the indications for the different homogenizing filters and scatter foils. A comparison of the dose rate of the Siemens 42 MeV and the BBC 35 MeV betatrons showed a large superiority of the former, especially at lower energies. (auth)

**20235** DOSAGE OF IMPLANTED GAMMA SOURCES. Busch, Manfred; Wolfart, Juergen (Univ., Freiburg i. B.). Strahlentherapie, 136: 437-47(Oct. 1968). (In German).

Mathematical and physical considerations showed that the tumor surface was the best basis for the dosage of implanted gamma-sources. The total radioactivity necessary to obtain a definite minimum dose depended linearly on the surface of the tumor area. The geometric form of the tumor—as it was shown by simple geometric figures—had negligible influence on this dosage rule. This was demonstrated on models with homogeneous volume or superficial distributions of radioactivity. The analogy conversion to discontinuous distributions as seeds, needles, and wires was outlined. In homogeneous distributions the error was of the order of ±15% for the most common geometrical forms of tumors. (auth)

**20236** EMERGENCY HAZARD PROTECTION AND CONCERNED EDUCATION AND TRAINING. Maruyama, Yoshimi; Miyoshi, Shoji (Japan Atomic Energy Research Inst., Tokyo). Anzen Eisei, No. 267, 1-9(1967). (In Japanese).

In Japan Atomic Energy Research Institute, there exist numerous facilities involved in hazards (and accidents), with total personnel about 1800, including five nuclear reactors, several critical facilities, special plants handling spent fuels or RI's, accelerators, and other chemical and physical laboratories. The keynotes of the safety measures in JAERI are: no hazard at all to the nearby populace either in normal or emergency situation; avoidance of such circumstances as to cause the loss of human life and bodily functions of Institute personnel; and contribution to the safety of future nuclear installations in Japan, through the research results and safety-control experiences. The emergency hazard protection and concerned education and training in JAERI are described in the following sections: facilities and site conditions of JAERI; features of the JAERI safety control, and its organization; statistics of the JAERI hazards and accidents; emergency measures and the safety-protection corps; education and training in safety and its protection; and training of the corps. (NSA of Japan)

**20237** PHYSICAL DOSIMETRY AND INSTRUMENTATION FOR LOW-ENERGY PROTON IRRADIATION OF PRIMATES. Boles, Larry A.; Blake, Kenneth R.; Parker, C. Varren Jr.; Nelson, John B. (Nuclear-Chicago Corp., Austin, Tex.). Radiat. Res., 37: 261-71(Feb. 1969).

The object of this program was to develop a method to irradiate primates with whole-body exposures to proton beams in the energy range from 5 to 28 MeV. A system to expand the external beam of the Oak Range Isochronous Cyclotron was devised. The spatial distribution of the beam was uniform within ±5% over a 20 × 40-cm rectangle, and for all energies above 5 MeV the energy resolution was less than 1.8 MeV full width at half maximum. The proton beam was extremely stable; all beam profiles were basically identical, and the center of the beam did not vary over 3 cm in any direction. A variable-volume ionization chamber was designed and fabricated for use in remotely measuring the relative intensity of the flux. Flux values were measured with a Faraday cup, and surface-dose calculations were made from tabulated values of $1/\rho$ dE/dX for muscle. The dose values were accurate within ±8% for all energies used except 5 MeV, where the energy straggling made the uncertainty ±10%. In all, 90 primates were irradiated at 28, 21, 14, or 5 MeV and given doses ranging from 500 to 2000 rads. (auth)

**20238** MEASUREMENTS OF DEPTH-DOSE DISTRIBUTIONS IN CYLINDRICAL PHANTOMS EXPOSED TO 28-MeV, 21-MeV, 14-MeV, OR 5-MeV PROTONS. Hardy, Kenneth A.; Mitchell, John C.; Allen, Stewart J. (School of Aerospace Medicine, Brooks Air Force Base, Tex.). Radiat. Res., 37: 272-82(Feb. 1969).

Thermoluminescent dosimeters (TLD) were used to measure the depth-dose distributions in cylindrical phantoms that were rotated about an axis perpendicular to nominal beams of 28-MeV, 21-MeV, 14-MeV, and 5-MeV protons. The empirical data presented illustrate that these TL dosimeters can be used to obtain reliable estimates of the depth-dose patterns resulting from exposures to protons in the energy range between 5 and 30 MeV. Good agreement was obtained both with theoretical predictions and by comparison with active ionization chambers. Measurements presented also indicate that the dosimeters used are energy-independent over this energy range. (auth)

**20239** RADIOTOXICOLOGY OF TRITIUM AND $^{14}C$ COMPOUNDS. Vennart, J. (Radiological Protection Service, Sutton, Eng.). Health Phys., 16: 429-40(Apr. 1969).

Maximum permissible annual intakes to blood of several tritiated compounds, namely, water, folic acid, corticosteroids, sex-hormones and thymidine, were estimated on the basis of average doses received by organs and tissues from experiments on rats. The values range from 10 mCi for tritiated thymidine and folic acid to 1 or 2 Ci for tritiated corticosteroids. Values for corresponding $^{14}C$ labeled compounds will, in general, be lower because of the higher energies of the $^{14}C$ beta-particles. Dosimetry in cells is considered, particularly in relation to tritium and $^{14}C$ labeled thymidine. Questions concerning the importance of inhomogeneity of absorbed energy in microscopic volumes are discussed in relation to the use of average dose as the basis for setting maximum permissible levels of dose and intakes of tritium and $^{14}C$ labeled compounds. (auth) (UK)

**20240** PATIENT DOSE IN DENTAL CINEFLUOROGRAPHY. Smith, N. J. D.; Heighway, W. P. (King's Coll. Hospital, London). Oral Surg., Oral Med., Oral Pathol., 27: 349-57(Mar. 1969).

Some values for the patient's dose during cinefluorography are given. The method used for obtaining these values is described, and some of the factors which contribute to the patient's dose are discussed. The question of a dose limit to volunteer subjects is explored. (auth)

**20241** MEASUREMENTS OF RADIOACTIVE NUCLIDES FROM FALLOUT IN NORWAY. Underdal, B.; Hauge, S. Nord. Veterinarmed., 20: 71-4(1968). (In Norwegian).

Radioactive fallout in Norway has been particularly high because of its geographical location and climatic conditions. Farming practices predispose to higher $^{90}Sr$ and $^{137}Cs$ concentrations in milk and other animal products, especially in northern and western Norway. Reindeer are an important meat product in northern areas and reindeer-meat was more contaminated than was the meat of other species. The data presented indicate an increase in radionuclides in animal products up to 1965; however, there is evidence of a reduction in the whole-body counts of adult Lapps between 1965 and 1966. Recognition of the need for assessing potential hazards to population samples, in relation to local farming and nutrition, is emphasized on the basis of these studies. (BBB)

**20242** DOSIMETRY IN PHOTOCHEMISTRY. Johns, H. E. (Univ. of Toronto). Photochem. Photobiol., 8: 547-63(Dec. 1968).

A method of dosimetry which is useful in analyzing complex photochemical reactions involving more than one photoproduct is described. This involves determining a photochemical cross section for each of the products, $\sigma_B$, $\sigma_C$ ...., and an absorption cross section $\sigma_a$ for the reacting species. The ratio $\sigma_B/\sigma_a$ is the quantum yield for production of product B. Where a number of photoproducts are produced simultaneously, it is convenient to express dose in terms of the average number of photons per $cm^2$ seen by each molecule in the vessel. This average can be calculated from the number of incident photons, the volume of the liquid, the absorbance and the path length. Experimental details of the irradiation facility which is convenient for such studies are presented. The method of dosimetry is illustrated using photochemical data for uracil and orotic acid in solution. (auth)

**20243** RADIATION MONITORING IN THE RADIOACTIVE LUMINISING INDUSTRY. Murayama, Yoshihiko (Nemoto Spec. Chemical Co., Ltd., Japan). Hoken Butsuri, 2: 166-72(Dec. 1967). (In Japanese).

Self-luminous compound emits a light by the excitation of the radiation. As a radiation source for self-luminous compound promethium-147 or tritium is used recently. In Nemoto Tokushu Kagaku Takaido Factory the radioactive luminous compound has been produced and applied to dials and hands of watches and clocks from 1960 up to the present. The working methods and the radiation monitoring such as personal control, air dust monitoring, surface contamination and wastes control in this factory are described. (auth)

**20244** X-RAY METHOD OF DETERMINING THE INTEGRAL ABSORBED DOSE OF SCATTERED RADIATION. Pospelova, I. I. (Central Scientific-Research Inst. of Roentgen Radiology,

Leningrad). Med. Radiol., 14: No. 2, 38-42(Feb. 1969). (In Russian).

A mathematical method of ratios for determining the value of absorbed energy of scattered radiation is presented. (auth)

**20245** INDUSTRIAL CREATION OF DECONTAMINATION WORK-SHOPS. Fournier, Ph.; Lachoviez, St. Atompraxis, 15: 48-51(Jan.-Feb. 1969). (In German).

Decontamination problems constitute a very important phase in the construction of nuclear installations. General principles of decontamination and the different processes used are reviewed and the necessity of decontamination "in situ" is underlined. The application of these principles when constructing industrial hot decontamination work-shops is considered by emphasizing the conditions of efficacity of treatment and security. (auth)

**20246** ENVIRONMENTAL CONTROL OF WORK SITES EXPOSED TO RADIATION HAZARD. Erdelyvari, Istvan. Fiz. Szemle, 18: 317-20(1968). (In Hungarian).

Radiation control of the environment at potentially hazardous work sites requires the determination of the gaseous and liquid effluents, ground waters, together with the background $\gamma$ radiation. Near large research centers, the drinking water supply, surface waters and agricultural products must be systematically examined. The air may be monitored continuously or periodically. The presence of Rn, Tn, and their daughters render the detection of the contamination of the atmosphere difficult. Potentially radioactive liquid streams should not be released directly into open sewer systems but should be sent to a retainment basin. Such basins and measuring wells are included in the monitoring system built at the Central Research Institute for Physics. Auxiliary areas near work sites, such as library and cafeteria are subject to direct control. The background is monitored continuously; if the present level is exceeded, an alarm is sounded. (TTT)

**20247** THE ROLE OF ENEA IN THE FIELD OF NUCLEAR LAW. Strohl, Pierre. OECD (Organ. Econ. Coop. Develop.) Observ., No. 38, 38-42(Feb. 1969).

One function of the European Nuclear Energy Agency (ENEA) is to promote the elaboration and harmonization of legislation relating to nuclear energy in its participating countries. In particular, it is required to formulate common rules for submission to governments as a basis for such legislation. This activity covers: the protection of workers and the general public against the risks of occupational disease and accidents in the nuclear industry; third party liability in the event of a nuclear incident and insurance against such liability; and the development of nuclear laws. Some features of a new European nuclear law, which is progressively coming into force, are described. The nuclear law is characterized by the novelty of the principles adopted. In the event of a nuclear incident, it is immaterial who is to blame or even if anyone is to blame. The operator of the installation where the incident originates is alone liable to compensate the damage caused to third parties, even if his conduct has been entirely blameless and the blame lies elsewhere, e.g., with a negligent supplier who has delivered defective equipment. The exclusive liability of the nuclear operator is offset by another rule imposing a statutory limit on the amount of compensation for damage which he is liable to pay, whereas under ordinary law, the person liable must in principle compensate in full for all the damage caused. Liability of the nuclear operator is accompanied by compulsory financial security for injured persons. Nuclear law is largely international. The international nature of nuclear third party liability in any event extends beyond the confines of Europe. The same concern for unification arises again in the ionizing radiation protection norms for workers and the general public which must be observed in nuclear installations. Various reasons for the international character of nuclear law are cited. (BBB)

**20248** RADIATION ISOEXPOSURE CURVES ABOUT A DENTAL CHAIR DURING RADIOGRAPHY. Rolofson, James W.; Hamel, Alfred; Stewart, Harold F. (Public Health Service, Rockville, Md.). J. Amer. Dent. Ass., 78: 310-19(Feb. 1969).

Ionization chamber dosimetry studies were made to evaluate the exposure of the dentist in dental radiography. Data collected for all the anterior upper periapical projections showed without exception that minimum exposure values occurred in the primary x-ray beam directly behind the dental chair, 0° to the direction of the central ray. The patient's head and the dental chair act as effective absorbers in reducing the primary beam to minimal exposure values. This projection usually gave maximum exposure directly behind the tubehead, 180° to the direction of the central ray. In this position, the ion chamber recorded maximum values because of the lack of shadow effect by the tubehead. A reduction in secondary radiation was seen with the short pointer cone and the short unlined cylindrical cone when compared to those of the lead-lined cone. For the lower anterior periapical projection, the positions of minimum and maximum exposure changed considerably. The isoexposure curves showed that the position of minimum exposure is located directly behind the tubehead in both cases. This minimum exposure probably results from the shadow effect of the tubehead. (BBB)

**20249** REFLECTION OF NEUTRONS BY HUMAN BODY. Tatsuta, Hatsumi; Ryufuku, Hiroshi (Japan Atomic Energy Research Inst., Tokyo). Nippon Genshiryoku Gakkaishi, 9: 700-4 (Dec. 1967). (In Japanese).

The reflection factor of neutrons by phantoms was determined experimentally. Two kinds of phantom were used in the experiments, resulting in well coinciding data. This phenomenon indicates that the reflection factor is determined by the surface tissue lying within several centimeters of the skin surface, and is independent of the size and shape of the phantoms. The reflection factor was found to fall only very slowly with energy, providing that a thermal neutron detector on the surface of the human body may be used to measure the dose-equivalent of neutrons of incident energies up to 10 keV. (auth) (NSA of Japan)

**20250** SOME CONSIDERATIONS OF SPECIAL CHARACTERISTICS OF MEASUREMENTS FOR RADIATION PROTECTION PRACTICE. Anzai, Ikuro; Yoshizawa, Yasuo (Tokyo Univ.). Hoken Butsuri, 2: 109-14(Sept. 1967). (In Japanese).

Some basic considerations were made on the special characteristics of measurements for radiation protection activities. It was emphasized that the measurement techniques should be thoroughly re-examined, not from the standpoint of pure radiation dosimetry, but from the standpoint of routine radiation protection practice. It is one of the most important characteristics that complicated uncertain factors are inevitably concerned with the measured value in the field of radiological protection. Some error-introducing factors in several measurement techniques were indicated and it was emphasized that these techniques are yet fully effective in spite of those quantitative uncertain factors which are difficult to evaluate. The accuracy of the measured value is allowed to be less precise unless that quantitative uncertainty produces the qualitative uncertainty which has a hindrance in the normal performance of the radiation protection activities. This important understanding, being interdependent with the necessity of simplification of the techniques, can make a drastic improvement of measurement method really possible. From the standpoint mentioned above, a typical example of the simplified method of urinary uranium analysis using sodium fluoride pellet was presented in which the trouble was remarkably reduced and the time required for analysis was shortened to one third of that of the former method. (auth) (NSA of Japan)

**20251** A THEORY FOR QUANTITATIVE ANALYSIS OF THE UNCERTAINTY IN EXTERNAL RADIATION MONITORING. Anzai, Ikuro; Yoshizawa, Yasuo (Tokyo Univ.). Hoken Butsuri, 3: 402-10(Dec. 1968). (In Japanese).

It is shown that the measured values in the field of radiological protection are inevitably concerned with the uncertain factors which can never be dissolved by mere improvement of measurement techniques. A single value measured by an external personnel monitor attached on a certain position on the surface of human body does not carry the informations of incident direction of the exposed radiation, and therefore the organ dose can not be estimated correctly by a single measured value of the personnel monitor unless information is provided of irradiation pattern or spacial distribution of the incident radiation. A basic matrix expression is given of the relationship between the measured value and the organ dose. On the basis of this fundamental equation the authors developed a probabilistic investigation in estimating the organ dose from a single measured value and gave a quantitative expression of the uncertainty in dose estimation, introducing a concept of Entropy which is popularly used in information theory. Some discussions are made on the elimination of uncertainty when more than one measured values are obtained or some qualitative informations are additionally given about the spacial distribution of incident radiation. (auth) (NSA of Japan)

**20252** SIMULATED EXPERIMENT OF THE SKY SHINE IN WATER. Matsumura, Toyozo; Okubo, Masaki (Mitsubishi Atomic Power Industry, Inc., Japan). Hoken Butsuri, 2: 151-4(Dec. 1967). (In Japanese).

Experimental discussion was made about the simulated experiment of the sky shine in water. Measurements of the dose rate of gamma-rays from a point source of $^{60}Co$ in an infinite water medium were made. Ionization chambers were used for measurement of the dose rate. A satisfactory agreement was obtained between dose buildup factor given by this experimental results in water and those given by the calculated results in air. It was shown that this

simulated experiment in water offers the valuable information concerning the sky shine from the results of this study. (auth) (NSA of Japan)

**20253** RADIATION DOSE ESTIMATION IN CRITICALITY ACCIDENT. 2. NEUTRON CAPTURE PROBABILITY OF PHANTOMS. Maruyama, Takashi (National Inst. of Radiological Sciences, Chiba, Japan). Nippon Igaku Hoshasen Gakkai Zasshi, 27: 1347-53(Jan. 1968). (In Japanese).

Measurements of the neutron capture probability were made for various shapes of phantoms in order to estimate the fast neutron dose after a criticality accident. All the phantoms used were polythene containers filled with a physiological salt solution. Neutrons used for the sodium activation were obtained from a Van de Graaff accelerator using the thick Be target. Using man shaped phantom it was found that differences in orientation may cause variations in the neutron capture probability up to 60% for the same incident neutron fluence. The variation of the capture probability with neutron energy was determined for the man shaped phantom. (auth) (NSA of Japan)

**20254** RADIATION HAZARDS FROM X-RAY DIFFRACTION EQUIPMENT. Robertson, M. K. (National Radiation Lab., Christchurch, New Zeal.). N. Z. J. Sci., 11: 433-9(Sept. 1968).

X-ray generators designed for use with crystallographic diffraction equipment have caused a significant number of radiation injuries. Hazards associated with the use of x-ray diffraction equipment are reviewed in detail. Radiation dose rates, measured on a typical unit, are reported, and the symptoms of exposure to such dose rates are described. Precautions and safety equipment, commensurate with the hazards, are also described. The most hazardous period for possible exposure by the primary beam is during the alignment of collimators and other equipment. In particular, the consequences following exposure of the lens of the eye must be recognized. Dose rates of scattered radiation were measured. At about 80 cm to one side of the uncollimated beam (4 cm diameter at 30 cm from the target) the dose rate of radiation scattered by air in the beam ranged from 0.04 mR/hr with a molybdenum target, zirconium filter, to 20 mR/hr with a copper target, no filter. (Both measurements at 36 kV, 20 mA). The International Union of Crystallography (1963) recommends a maximum dose rate of leakage radiation of 2 mR/hr, at 25 cm from any accessible surface. (BBB)

**20255** MEASUREMENT OF DOSE RATES OF A HIGH-LEVEL GAMMA IRRADIATION FACILITY. Weng, P. S. (National Tsing Hua Univ., Hsinchu, Taiwan). Hoken Butsuri, 2: 160-5(Dec. 1967).

LiF thermoluminescent dose meters were used to measure the dose rates in a high-level gamma irradiation facility which provides a wide range in dose level and various irradiation areas. A comparison of the discrepancies between observed data and calculated data based on a cylindrical source, point source, and line source is included. (NSA of Japan)

**20256** RADIATION PROTECTIVE CLOTH. Tabuchi, Yoshio Japanese Patent 1968-29040. Nov. 28, 1968. Filed Oct. 20, 1965.

A method is described for producing a cloth that is lightweight and flexible, has good ventilation and texture, and that is suitable for use in radioprotective clothing. The material consists of a spongy base of a synthetic resin with many voids to which are added powders of the compounds of lead, iron, etc.; a thin film and a thin cloth, covering both surfaces of the base with many tiny ventilating holes penetrating inward from both surfaces. A hole from one surface is displaced from the corresponding hole from the other surface and ventilation paths connect the two holes through voids. (NSA of Japan)

**20257** THE UNWANTED RADIATION ASSOCIATED WITH SEVERAL TYPES OF $\beta$ RADIATIONS. Born, W. (Albert-Ludwigs-Univ., Freiburg i. B.). Nautarzt, 19: 312-17(July 1968). (In German).

Some misuses of $\beta$ irradiators in medicine that result from lack of knowledge or oversights are discussed. These include, as examples, improper use of filters and shielding, misapplication of the inverse square law for estimating doses and lack of attention toward use and application of proper and adequate measures for genetic protection of various populations exposed to irradiation, procedures suggested for protection of gonads, and hazards during irradiation treatment of hemangiomas. Contribution of various types of metals used for $\beta$ irradiators that contain Ni and Al which produce unwanted radiation are discussed briefly. (BBB)

**20258** TENTATIVE APPROACH FROM THE INFORMATION THEORY TO THE PROBLEM OF INTERNAL CONTAMINATION. Anzai, Ikuro; Yoshizawa, Yasuo (Tokyo Univ.). Hoken Butsuri, 3: 295-303(June 1968). (In Japanese).

In a former paper by the authors it has been emphasized that the measured values in the field of radiological protection are inevitably concerned with the uncertain factors which can never be dissolved by mere improvement of measurement techniques. The concept of Entropy popularly used in information theory was introduced in the present paper in order to give a quantitative estimation of the uncertainty which appears in the problem of internal contamination measurement. Body retention of the radioactive contaminant after a single intake changes with time according to the physical decay and biological elimination. Hence uncertainty is introduced in case of estimating the initial amount of contamination from a single value of one-point sampling and measurement. When the detected body burden is q ($\mu$Ci), the probability with which the initial intake $Q_0$ ($\mu$Ci) may have been over the pre-decided reference value $q_0$ ($\mu$Ci) was given as follows, $p\ (Q_0 \geq q_0) = 1 - (T_{eff}/\tau)\ \log_2\ (q_0/q)$ where $\tau$ is the interval of measurement and $T_{eff}$ is the effective half life. Apparently, $p\ (Q_0 < q_0) = (T_{eff}/\tau)\ \log_2\ (q_0/q)$. A graphical presentation of the entropy was also given and the effectiveness of internal contamination sampling program was discussed. (auth) (NSA of Japan)

**20259** ENVIRONMENTAL PLANNING: A HEALTH PHYSICISTS VIEW. Whipple, G. Hoyt (Univ. of Michigan, Ann Arbor). Amer. J. Public Health, 58: 1410-13(Aug. 1968).

Concepts, standards, and philosophy of radiation protection as they are applied to the environment are discussed, and how these principles can be applied to the problems of nonradioactive pollutants, is also considered. The standard for radiation control in the environment is 500 mrem/yr added to the natural background. This figure has resulted from years of deliberation by national and international organizations of scientists. The principal effects which it is believed radiation may produce, even at very low levels, namely, increased incidence of leukemia and genetic mutations, and accelerated aging. Extensive laboratory experiments have failed to show thresholds for these effects of radiation. Environmental quality standards compatible with 500 mrem/yr are established for the amount of each radioisotope, which will produce the limiting dose rate in the body. Then, the daily intake, which will maintain the body content at the level producing the limit dose rate, is calculated for each radioisotope. Daily intakes are calculated in this way for both inhalation and ingestion, in both soluble and insoluble forms. Using the concepts presented, with judgment and some arbitrary assumptions, the health physicist is able to calculate the maximum rate of release for some of the radioisotopes which disperse readily in the environment, such as $^{85}Kr$ and $^{3}H$. With more assumptions, he can estimate the maximum rate of nuclear power production, nuclear explosive detonations, and isotope use in industry, medicine, research, and other areas, compatible with the environmental quality standards. (BBB)

## Medicine

*Refer also to abstracts 19757, 19888, 19894, 19948, 19953, 19954, 19960, 19970, 19985, 20178, 20334, 20368, 20369, 20397, 20409, and 21206.*

**20260** (BNL-50058, pp 134-60) SUBLETHAL-LETHAL RADIATION DAMAGE AND REPAIR IN MAMMALIAN CELLS. Elkind, M. M.; Kamper, C.; Moses, W. B.; Sutton-Gilbert, H. (National Cancer Inst., Bethesda, Md. Lab. of Physiology).

Chinese hamster cells were exposed to actinomycin D and x radiation. It was found that actinomycin D enhanced x-ray killing in qualitatively the same way whether cells were treated before or after single doses, or between fractionated doses. This enhanced effect could not be attributed to a nonspecific stress resulting from the drug treatment, and was evident at drug concentrations which were, by themselves, nontoxic. The age-response pattern of cell killing due to actinomycin D alone was similar to, but not identical with, the pattern of killing due to x rays alone. Treatment with toxic concentrations of actinomycin D at varying intervals after an x-ray dose displayed a two-dose effect reminiscent of two-dose x-ray data when an accounting was made of the differences in the age-response patterns of these agents. Fractionation survival curves demonstrated the repair of a form of damage with which actinomycin D interacted. Treatment after irradiation with concentrations of actinomycin D that were essentially nontoxic also showed a time-dependent loss of interactive ability. Further, the time course of this loss seemed to be similar to the time course of repair of sublethal x-ray damage. General points that can be added are as follows: While most of these results referred to late S cells, the x-ray lethal response of cells at all ages was enhanced by actinomycin D. Accordingly, it may be true that the action of this drug was qualitatively the same in cells of all ages. Very low

concentrations of actinomycin D were sufficient to demonstrate a clearly apparent interactive effect. (C.O.)

**20261** (BNL-50058, pp 190-211) IMMUNOLOGICAL AND HEMATOLOGICAL ASPECTS OF RECOVERY: IMPLICATIONS FOR THERAPEUTIC USE OF BONE MARROW GRAFTS. van Bekkum, D. W. (Gezondheidsorganisatie TNO, Rijswijk (Netherlands). Radiobiologisch Instituut).

Various factors involved in hematopoietic recovery are reviewed and discussed. These include composition of microflora and bone marrow cell survival; lymphopoietic recovery in relation to antibody production and homograft reactivity; secondary disease in radiation chimeras as a model for the study of lymphatic recovery; secondary disease in the absence of a foreign cell graft, and implications for bone marrow transplantation in primates. The discussions led to the conclusions that the radiosensitivities of the hematopoietic and the lymphopoietic cells were probably very similar. Recovery of both systems did occur, and that possibly this capacity was slightly better developed in the lymphoid system. A sufficient supply of thymus-independent lymphoid cells effectively compensated for the inability of the thymus-dependent population to proliferate. The overall conclusion reached was that if the radiosensitivity of the thymus epithelium and the interrelation between thymus and lymphopoiesis are similar in primates, the problems encountered in homologous bone marrow transplantation might be more complicated than is now foreseen. (C.O.)

**20262** (BNL-50058, pp 241-62) MECHANISMS OF ACTION OF SULFUR-CONTAINING RADIOPROTECTORS. Bacq, Zenon-M. (Liege Univ. (Belgium). Laboratoire de Recherches pour la Protection des Populations Civiles); Goutier, Roland (Centre d'Etude de l'Energie Nucleaire, Mol (Belgium)).

The classical theories of hypoxia, mixed disulfide formation, free radical scavenging, or hydrogen transfer that have been proposed for explanation of chemical protection by sulfur-containing substances against ionizing radiation are discussed. It was concluded that they were not adequate for protection in the case of the whole mammal. It was shown that organic sulfur-containing radioprotective compounds markedly affected metabolism and cellular ultrastructures of mammalian organs by delaying mitosis and DNA synthesis. A hypothesis was submitted that these biochemical changes increased the efficacy of the repair system or protected it from radiation damage. (C.O.)

**20263** (BNL-50058, pp 284-302) STUDIES ON THE EFFECT OF CHEMICAL TREATMENT ON THE SURVIVAL OF REPEATEDLY IRRADIATED MICE. Sugahara, T.; Tanaka, T.; Nagata, H. (Kyoto Univ. (Japan). Dept. of Experimental Radiology).

Various chemical compounds were tested by administration to mice between repeated exposures to sublethal doses of radiation. A few different kinds of chemicals appeared to increase the tolerance to repeated irradiations. Among them a nucleotide mixture (Nucleton), which is an alkaline-hydrolyzed product of yeast RNA composed mainly of four kinds of 3'-nucleotides of RNA, was studied in its biochemical and cellular aspects. The survival time of mice irradiated once per week until death was increased significantly when they were treated with the nucleotide mixture. This effect seemed to be common to nucleic acid precursors except 5'-nucleotides. It was considered that the increase in survival was possibly because of enhancement of recovery by the chemicals, but that the effect on recovery seemed to be restricted to sublethal damage. In regenerating mouse liver, the nucleotide mixture was found to restore the depression of DNA synthesis induced by radiation. The biological implication of this effect with respect to the increase in survival of repeatedly irradiated mice was not clear. Cellular kinetics in the blood-forming system were followed in mice treated with the mixture. In spite of the slight effect observed on survival in L cells in culture, no significant increase of survival of stem cells in the treated mice was observed with colony formation in the spleen as a criterion. A hypothesis suggesting that the treatment played an important role in maintaining the level of functional cells at the expense of their stem cells is presented. (C.O.)

**20264** (CEA-tr-A-1945) RESULTS OF SCINTIGRAPHIC EXAMINATIONS OF BREAST TUMORS. Buchwald, W.; Diethelm, L.; Haas, J. P.; Wolf, R. Translated into French from pp 549-53 of Radioisotope in der Lokalisations-Diagnostik, Germany, 1967. 10p. (In French). Dep.

In scintigraphy of breast cancer, $^{197}HgCl_2$ should be used. The scintigraphic exploration is in this case an important complementary method to the usual clinical and radiological diagnostic methods. It should be used principally to establish differential diagnosis of chronic mastopathy or cancer. In scintigraphy of the parasternal lymph nodes with colloidal $^{198}Au$, a positive diagnosis in individual cases is problematic, although there are certain aspects of the scintigrams that can be considered as typical. For early scintigraphic detection of bony metastases, $^{85}Sr$ must be used. (tr-auth)

**20265** (CONF-680507-, pp 124-42) RADIATION-TRAUMATIC COMBINATION INJURIES. Messerschmidt, Otfried (Freiburg Univ. (West Germany). Radiologisches Institut). (In German).

Radiological-surgical combined injuries were the most frequent injuries in Hiroshima and Nagasaki; they composed about 50 to 70% of all injuries to the population. Since many symptoms indicate that combination injuries are not easily conceived as individual symptoms of radiation injury and surgical injury, but that in this type of injury combinations a completely different clinical picture can emerge, it appears legitimate to regard combination injury as a clinical concept. In some animal experiments, the question of the symptomatology and the patheogenesis of the combination injury was studied. It was confirmed that whole-body irradiation and other types of injuries affect each other to a significant degree. The degree of lethality in radiation-surgical combination injury was affected especially by the time factor, which means both the sequence in which the whole-body irradiation and wound occur and the time interval between the two types of injury. It was also shown that the type of surgical wound affects the gravity and the pattern of the clinical picture. Open and closed skin wounds, compression syndrome (tourniquet), laparotomy, and burns show different lethal behavior when they are combined with whole-body irradiation. In further investigations on mice and rats the pathophysiology of combination injury as a result of the interaction of whole-body irradiation and open skin wounds was studied. The wound healing process was investigated, hematological controls and electrophoretic determinations of the blood protein fractions were carried out, and biological, histological, and bacteriological investigations were undertaken. (tr-auth)

**20266** (CONF-680507-, pp 154-61) REEXAMINATION OF BIOLOGICAL RECOVERY RATES AND EQUIVALENT RESIDUAL DOSES. Leong, G. F.; Ainsworth, E. J.; Page, N. P.; Taylor, J. F.; Still, E. T. (Naval Radiological Defense Lab., San Francisco, Calif.).

The importance of estimating the extent of injury and recovery in man following nuclear detonations for decisions relating to operational procedures is discussed. The formulation of a model for recovery from radiation injury led to the development of the ERD (equivalent residual dose) concept to provide a more reliable prediction of the biological and medical consequences following radiation exposure in man. Comparisons were made in $LD_{50}$ responses, hematological responses, and patterns of recovery in multiple mammalian species ranging from size from laboratory rodents to large domestic animals under controlled conditions. By studying radiation responses of animals representing a broad spectrum of species, it was felt that a better estimate of the recovery rate for man could be derived. Because of the variability in the patterns of recovery that were observed for multiple mammalian species, it was thought that generalizations describing the recovery from radiation injury as a single component exponential could not be made. (H.L.W.)

**20267** (NEIC-RR-26) RAPORT Z PRAC BADAWCZYCH PROWADZONYCH W 1966 ROKU. (Annual Report on the Research Work of the Institute for 1966). Jasinskiego, W. (Instytut Onkologii, Warsaw (Poland)). 1967. 148p. (In Polish). Dep.

Progress is reported on research at the Institute of Oncology in Poland. Studies were conducted on the treatment of malignant tumors. Highest frequencies of carcinomas were found to be: cervical cancer, cancer of the skin and lip, mammary cancer, cancer of the alimentary tract, and bronchial cancer. The influence of environmental factors on mortality rates was investigated. Research in experimental oncology included studies on cytogenetics, immunology, biochemistry, and histochemistry. Investigations were conducted on the pathology of stomach cancer with special attention to the relation between structure and clinical progression of the disease. Other studies were conducted on clinical chemistry, improvements in $\gamma$ and x-ray therapy techniques, and clinical applications of radioisotopes. (H.L.W.)

**20268** THE INFLUENCE OF pH ON THE RADIOPROTECTIVE ACTION OF CYSTEAMINE. Burlin, Terence E.; Magnus, Ian A.; Szur, Leon (Inst. of Dermatology, London). J. Invest. Dermatol., 52: 181-4 (Feb. 1969).

Groups of 12 to 20 male mice (Strain A Albino) of ca 10 wk of age and 20 g in weight each had had the flank hair coat plucked three days previously and were irradiated with 50 kVp x rays without being anesthetized. Exposures of 500, 1,000, 1,500, and 2,000 R were made on 1 cm diameter areas of bare skin at a rate

of 3,800 R/min. Mice were given 3 mg of cysteamine in 0.3 ml volumes intraperitoneally 10 to 40 min before irradiation. Identical experiments were performed with cysteamine HCl that was in a solution of 30 mg/ml in 0.85% saline at pH 4.5 to 7.8. The state of the mouse hair coat was then determined. It was concluded that the protective effects of cysteamine was dependent on the pH at which it was injected into the peritoneum. Maximal protection was at a pH of 7; protection was absent or slight at pH 4.2 and 5.5. A marked change in the protective action of cysteamine was indicated by the dose reduction factor that took place between pH 5.5 and 6.8. (C.O.)

**20269** INULIN LABELED WITH $^{51}Cr$ FOR DETERMINATION OF GLOMERULAR FILTRATION RATE. Materson, Barry J.; Johnson, Albert E.; Perez-Stable, Eliseo C. (Univ. of Miami, Fla. Miami Veterans Administration Hospital, Fla.). J. Amer. Med. Ass., 207: 94-6(Jan. 6, 1969).

Glomerular filtration rate (GFR) was determined in 12 patients by simultaneous clearance of inulin and inulin labeled with $^{51}Cr$. Paired GFRs calculated by the C = UV/P formula showed excellent correlation ($r \pm 0.995$; $P < 0.001$; $y = 1.01x - 2.03$, where y indicates clearance of inulin $^{51}Cr$, and x indicates clearance of inulin). The clearance ratio was 0.975. Determination of GFR with inulin $^{51}Cr$ proved to be faster, cheaper, and more practical than with inulin. This compound makes GFR determinations readily available for clinical use. (auth)

**20270** LUNG CANCER FOLLOWING ATOMIC RADIATION. Wanebo, C. K.; Johnson, K. G.; Sato, K.; Thorslund, T. W. Amer. Rev. Respirat. Dis., 98: 778-87(1968).

Between 1950 and 1966, the incidence of lung cancer was increased beyond normal expectation in persons exposed to a radiation dosage of 90 or more rad during the atomic bombings of Hiroshima and Nagasaki. In a large life-span study sample, the ratio of observed to expected death certificate diagnoses was 1.9, and the ratio of principal autopsy diagnoses, 2.15. In a clinical adult health study sample (for which ascertainment must be nearly complete), the ratio was 1.6. These findings suggest an increased risk of lung cancer following atomic irradiation similar to that reported for patients undergoing radiotherapy for ankylosing spondylitis. Smoking histories pointed to an increased risk of lung cancer among smokers of either sex. No significant differences were noted between more heavily exposed survivors with lung cancer and other subjects with lung cancer when comparisons were made as to age at onset of disease, presence of other primary neoplasms, histologic type, or other epidemiologic factors (occupation, smoking, and tuberculosis) commonly associated with an increased risk of lung cancer. (auth)

**20271** CONTRIBUTION TO SCINTIGRAPHY OF THE SALIVARY GLANDS. Fridrich, R.; Wey, W. (Univ., Basel). Schweiz. Med. Wochensch., 98: 335-8(Mar. 2, 1968). (In German).

The advantages of using $^{99m}Tc$ for salivary gland scintigraphy are that their shape, size, and position can be ascertained percutaneously. By serial studies each of the glands can be detected and their secretory function judged. It is possible that $^{99m}Tc$ will help in study of the physiology of salivary secretion, although this would require considerably more study. (BBB)

**20272** STUDIES ON THE EFFECT OF HYPOXANTHINE-RIBOSIDE UPON RADIATION INJURIES. PART 1. THE INFLUENCE IN MICE EXPOSED TO RADIATION. PART 2. THE INFLUENCE UPON PERIPHERAL BLOOD FINDINGS OF RADIATION WORKERS. Takahashi, Teiichiro; Yoshikubo, Kunihiko (Tokyo Jikeikai School of Medicine). Tokyo Jikeikai Ika Daigaku Zasshi, 82: 109-25(May 1967). (In Japanese).

The therapeutic effect of hypoxanthine-riboside on radiation injuries was studied. The results obtained were as follows: Mice of ICR-, Swiss Albino (S.A.)-, and C3H strains weighing about 20gm. were subjected to a single whole-body x irradiation (180 kvp) with a dose of 513.26R, and subsequently the drug and/or other drugs were subcutaneously injected daily for a week. The 20 day survival rate of ICR-strain mice was 15% in intact control animals, 50% in animals administered this drug, and 75% in animals administered this drug in combination with Moriamin S containing essential amino acids. The 20 day survival rate of S.A.- and C3H strain mice were 20% and 5%, respectively, in intact animals, 75% and 50% in animals administered Moriamin S, and 50% and 10% in animals administered combined adenine and carbazochrome (Ad-Cch). The restoration of body weight of irradiated mice was promoted generally by all drugs, but in S. A. strain mice it was not enhanced by Ad-Cch. The drug was administered to 47 radiation workers for a week with a daily dose of 12 tablets (2.4gm.), and its effect was studied by peripheral blood findings before and after administration. After administration of this drug, hemoglobin, red cell count, white cell count, and hematocrit increased, but platelet count decreased. Its effectiveness on leucopenia was above 85%. From the above results, it seems that the drug is effective for reducing radiation injuries. (NSA of Japan)

**20273** RADIOACTIVE COLLOIDAL GOLD IN THE TREATMENT OF CHRONIC SYNOVIAL EFFUSIONS. Makin, Myer; Robin, Gordon (Hadassah Univ. Hospital, Jerusalem). Proc. Roy. Soc. Med., 61: 908-10(Sept. 1968).

Clinical studies and animal experiments on the distribution and effect of intra-articularly injected $^{198}Au$ colloids are reported. In patients with synovial effusion, a dose of 10 mCi was used after an assessment of the synovial surface area for the knee-joint and an arbitrary dose of 3 mCi was given in ankle joints. Such a dose should give a synovial radiation dose of about 2000 rad. With most patients, following the injection there was a marked increase in the effusion, most noticeable about a week after the injection. To assess the site and the mode of action of the radiation and its local and systemic irradiation effect, surface scintillation counts were carried out at intervals after the injection. The results showed that the greatest concentration of radioactivity remained in the vicinity of the injected joint and that there was only a small degree of lymph spread. Autoradiographic studies on rabbits following the injection of $^{198}Au$ into knee joints showed that, after the initial deposit of the radioactive particles on the joint surface, there was a rapid transference of the radioactivity into the superficial synovial cells and later into the subsynovial layer. These experiments confirmed the clinical evidence that there is a specific synovial uptake of radiogold. Due to this specific uptake and the low tissue penetration of the $\beta$ particles, the major portion of the radiation effect is directed against the synovium and the danger of radiation damage to surrounding tissue is minimal. (BBB)

**20274** PULMONARY SCINTIGRAPHY. CONTRIBUTION OF $^{99m}Tc$ TO THE MULTIPLICATION OF VIEWS. de Vernejoul, Pierre; Ruff, Francois; Even, Philippe; Kellershohn, Claude; Brouet, Georges (Service Hopitalier Frederic Joliot, Orsay, France). Presse Med., 75: 2757-62(Dec. 25, 1967). (In French).

The advantages of labeling human serum albumin with $^{99m}Tc$ instead of $^{131}I$ for pulmonary scanning are reviewed and discussed. These include the short half life of $^{99m}Tc$, which is 6 hr, the low irradiation dose even when relatively large doses of several mCi of $^{99m}Tc$ are injected, and the increased speed at which scanning can be performed as compared to when $^{131}I$-labeled human serum albumin is used. The 140-keV energy of $\gamma$ radiation from $^{99m}Tc$ is lower than that from $^{131}I$, and permits multiple views, such as from front, side, back, and obliquely to be made without interference or overlapping of one area over another. Examples of the equipment and techniques used are illustrated and described. (BBB)

**20275** FUNDAMENTAL CONCEPTS IN BONE–BLOOD FLOW STUDIES. Kane, William J. J. Bone Joint Surg., 50A: 801-11(June 1968).

Fundamental concepts of isotope-clearance methods, early studies in the field, and some present areas of investigation are discussed. A brief resume of the theoretical background of the clearance concept and the indicator dilution principle is presented. Various uses of $^{32}P$ for determination of bone viability, $^{51}C$ for evaluation of blood flow in bone, $^{85}Sr$ or $^{47}Ca$ for studies of blood-bone flow are reviewed in detail. Problems associated with these studies are discussed and methods that may improve studies of this type are evaluated. A summary of the quantitative results obtained by various authors using $^{49}Ca$, $^{47}Ca$, $^{85}Sr$, $^{87}Sr$, $^{18}F$, $^{42}K$, $^{86}Rb$, and $^{51}Cr$ is presented. Clearance techniques for measurement of blood flow with $^{42}K$ and $^{86}Rb$ are reviewed in detail. (BBB)

**20276** A NEW RESEARCH TECHNIQUE TO DETERMINE CHANGES IN BLOOD CAPILLARY FLOW. Olsen, William R. (Univ. of Michigan Medical Center, Ann Arbor). Arch. Surg., 97: 831-5(Nov. 1968).

A method to measure capillary blood flow in the nonanesthetized animal without surgical trauma by the technique of tissue blood $^{42}K$ uptake ratio is described. From nine to 64 sec after a single intravenous injection, the amount of $^{42}K$ in a tissue indicates the amount of blood that traversed the capillaries of that tissue if allowance is made for the effect of the total dose of $^{42}K$ injected. The amount of $^{42}K$/tissue was related to the $^{42}K$/ml of aortic blood if the hemodynamic equilibrium of the animal was unchanged. Within the upper limits imposed by K toxicity and the lower limits of $^{42}K$ detectability, the dose of $^{42}K$ had little effect on this relation. The ratios for myocardium, adrenal, kidney cortex, and muscle indicated the relative blood flow to the organ. The difference of the ratio for a specific tissue between two hemodynamically dissimilar groups of animals reflected direct changes in flow to that tissue. There are several advantages of this technique. It measures only capillary flow and the error imposed by direct arteriovenous flow on methods which measure only large vessel

flow was avoided. Within reasonable limits the ratio was independent of the dose of $^{42}K$, and the errors in determining body weight, blood volume, cardiac output, exact dilution of the isotope in the carrier, and the decay ratio of $^{42}K$ are eliminated. (BBB)

**20277** RADIATION REACTION IN ATAXIA TELANGIECTASIA. Morgan, John L.; Holcomb, Thomas M.; Morrissey, Robert W. (Lackland Air Force Base, Tex.). Amer. J. Dis. Child., 116: 557-8 (Nov. 1968).

An untoward response to radiotherapy in a patient with ataxia telangiectasia is reported. A 9-yr-old child was diagnosed as having ataxia telangiectasia at age seven, and after the appearance of a mediastinal mass two yr later and confirmation of Hodgkin's disease by scalene node biopsy, radiotherapy was initiated. Rapid deterioration of the patient's condition and marked radiation reaction necessitated discontinuance of this mode of treatment. Radiotherapy, with a planned tumor dosage of 4000 rad to the mediastinum and 3000 rad to the supraclavicular regions, was given by $^{60}Co$ $\gamma$. Dysphagia started within two weeks after the onset of radiotherapy, and at three weeks the patient had developed esophagitis thought to be secondary to the radiotherapy. Radiotherapy was discontinued after 34 days because the child's condition had deteriorated. He had received a mediastinal tumor dose of 2750 rad through opposing anterior and posterior portals, and 2750 rad to each supraclavicular area. Total skin dose was calculated to be 2843 rad to the anterior portion of the chest, 2652 rad to the posterior portion of the chest, and 2750 rad to the anterior supraclavicular areas. The severe dysphagia persisted and the child died. The postulated cause of death was respiratory failure due to pneumonia and lymphomatous pneumonitis. The adverse reaction of this patient was similar to the experience reported previously by other investigators and suggested need for caution in the use of radiation for treating patients with malignancy and ataxia telangiectasia. (BBB)

**20278** PREOPERATIVE RADIOTHERAPY OF RENAL-CELL CARCINOMA: A FEASIBILITY STUDY. Lacy, Sushil S.; Cox, Clair E.; Blake, Damon (Bowman Gray School of Medicine, Winston-Salem, N. C.). Amer. Surg., 33: 943-8 (Dec. 1967).

Preoperative radiation therapy in patients with renal adenocarcinoma was studied to determine patient tolerance and the effect of therapy on subsequent surgical procedure. X-ray treatment was given 5 days/week at the rate of 175 to 225 R/day. With $^{60}Co$ the tumor-dose range was from 300 R/day in four weeks to 5000 R in five weeks, calculated at the midplane. Patients treated with 250 kV x rays received 3000 R in $3\frac{1}{2}$ to 4 weeks. There was no significant depression of bone marrow activity. Radiotherapy produced significant depression of renal function in the affected kidney, but there was no evidence of functional depression in the contralateral kidney. The only consistent subjective complaints were mild nausea and mild gastrointestinal dysfunction. No objective or subjective side effects required discontinuation of therapy. There was never any distinct evidence of significant hepatic, splenic, gastric, spinal cord, or intestinal toxicity. (BBB)

**20279** GASTRIC IRRADIATION IN THE TREATMENT OF PEPTIC ULCER. Clayman, Charles B.; Palmer, Walter L.; Kirsner, Joseph B. (Univ. of Chicago). Gastroenterology, 55: 403-7 (Sept. 1968).

Effects on the stomach, clinical results, and complications following irradiation of the stomach for peptic ulcer are reported. With 250 kV x rays a skin dose was selected such that the combined daily contributions to the fundus from both portals provided a tissue dose of 160 rad minimum. Thus, in 10 treatment days the gastric fundus received a minimum tissue dose of 1600 rad. Irradiation gastritis resulted, with a temporary, necrotizing inflammation of the mucosa and submucosa of the stomach, with irregular destruction of parietal cells. The irradiation gastritis was characterized gastroscopically by hyperemia, hemorrhage, edema, and adherent mucous exudate. The effect of irradiation upon gastric secretion usually became apparent within three weeks after the completion of treatment. Substantial decrease in acid secretion were noted in 1026 of the 1485 patients (70%). In almost all of these patients, the course of peptic ulcer improved. Apart from transient mild to moderate nausea and tanning of the skin at the site of the portals, side effects were few. There were no symptoms attributable to the temporary achlorhydria. Radiation skin burns were limited to a few patients given second courses of irradiation, a procedure no longer recommended. One patient developed symptoms and electrocardiographic changes compatible with pericarditis; this subsided over a period of 2 or 3 weeks. No significant differences in the incidence of neoplasms among these gastric-irradiated patients were seen when compared with a carefully matched control group. (BBB)

**20280** RADIATION THERAPY IN THE MANAGEMENT OF BLADDER NEOPLASMS. Brady, Luther W.; Fraust, Donald S.; Gislason, G. J. (Hahnemann Medical Coll., Philadelphia). J. Med. Soc. N. J., 64: 33-7 (Jan. 1967).

Complications are reported for 54 patients treated with a median tumor dose of 6300 rad in a median elapsed time of 56 days and six patients who received radiation therapy preoperatively for a calculated tumor dose of 4000 to 6000 rad delivered in 26 to 39 elapsed days with total cystectomy following in six to 12 weeks after the completion of the radiation therapy. The complications observed varied from mild to major. Mild complications were seen in 42 patients who developed cystitis, dysuria, or proctitis persisting for six weeks beyond the completion of radiation therapy. Moderate complications were seen in nine patients and included persistent cystitis extending beyond six weeks after treatment, persistent proctitis extending six weeks beyond treatment, or bladder telangiectasia without severe bleeding. The past history in seven of these nine demonstrated previous major pelvic surgery. Major complications included persistent rectal or bladder bleeding, a contracted bladder, ulcerations of the bladder or rectum, fistula formation, or death due to complications of radiation therapy. Of the groups three patients exhibited major complications. Ulceration of the bladder was seen in one patient and fistulae occurred in two. The fistulous tract developed between the bladder and the abdominal wall. (BBB)

**20281** OPERATION, EXTERNAL IRRADIATION, RADIOACTIVE ISOTOPES, AND CHEMOTHERAPY IN TREATMENT OF METASTATIC OVARIAN MALIGNANCIES. Villasanta, Umberto; Bloedorn, Fernando G. (Univ. of Maryland, Baltimore). Amer. J. Obstet. Gynecol., 102: 531-6 (Oct. 15, 1968).

In 169 patients with malignant ovarian tumors, three modes of therapy were used including: operation and external irradiation; operation and irradiation plus radioactive colloidal gold; and operation, irradiation, and chemotherapy. Complications of treatment and survival were analyzed in relation to extension and histologic type of the tumor and type of therapy used. External irradiation was started seven to 20 days postoperatively. Colloidal $^{198}Au$ in doses between 100 and 200 mCi in 250 ml or more of saline was given in a single intraperitoneal injection, usually two to three days after operation. In these patients the external irradiation was started three to four weeks after administration of the $^{198}Au$ to allow for bone marrow recovery. Chemotherapy consisted of intraperitoneal instillation, at the time of operation with the abdomen still open, of 46 to 60 mg of triethylenethiophosphoramide (Thio-TEPA) in saline solution, followed by periodic administration of the same or similar drugs. Four of 41 patients treated with $^{198}Au$ developed intestinal obstruction requiring exploratory laparotomy and were found free of the original malignancy. Two of these four patients died of repeated episodes of intestinal obstruction and postmortem examination confirmed the absence of carcinoma. No correlation was found between intestinal obstruction, the amount of colloidal gold used, and dose of external irradiation administered. Combination operation and irradiation therapy were well tolerated and offered good results. Addition to this combined therapy of $^{198}Au$ or chemotherapy prolonged survival and offered a more comfortable and useful life but did not increase the cure rate. (BBB)

**20282** TREATMENT OF CHRONIC LYMPHATIC LEUKEMIA BY EXTERNAL IRRADIATION. Begemann, H.; Loose, W.; Trepel, F.; Pichlmaier, H. (Staedtische Krankenhaus, Munich). Klin. Wochensch., 46: 673-4 (June 15, 1968). (In German).

A 67-yr-old patient with chronic lymphatic leukemia was irradiated with a portable $^{90}Sr$ source attached to an arm for 45 days. Changes in the lymphocyte, granulocyte, thrombocyte, and erythrocyte counts in blood and results of serum electrophoresis studies were observed for 51 days before and 167 days after the irradiation was given. The small lymphocytes decreased more than the large lymphocytes, and in the bone marrow lymphatic infiltration decreased from 51 to 26%. The granulocytes, thrombocytes, and erythrocytes were relatively unaffected by the irradiation treatment, which was well tolerated by the patient. The remission produced by the irradiation treatment lasted for more than five months. (BBB)

**20283** TREATMENT OF CROCKER-SARCOMA 180 OF MICE WITH COMBINED X RADIATION AND CHLORPROMAZIN. Barth, Gunther; Krieg, Robert; Valentiner, Werner (Justus-Liebig-Univ., Giessen, Ger.). Strahlentherapie, 136: 588-95 (Nov. 1968). (In German).

Experiments were carried out on 270 white mice, NMRI strain. The results showed that the administration of Megaphen resulted in a significant inhibition of the growth of a nonirradiated tumor, Crocker-sarcoma, when compared to control animals. There was no difference when the injection was done near the tumor or at distance. The association of Megaphen whether close or at distance and radiotherapy resulted in a significant reduction of the

tumor volume, compared to the association of radiation and stabilizator only, or to irradiation alone. The survival of the animals associatively treated with the commercially available product was significantly higher compared to those treated associatively with stabilizator only. The survival was also higher compared to those treated only by radiation. A cause of the higher radiosensitivity could be the antiphlogistic activity of chlorpromazine and a synergism between chlorpromazine and the radiation effect. (auth)

**20284** PROTECTION AGAINST IONIZING RADIATION AT THE CELLULAR LEVEL, ASSESSED BY VARIOUS PARAMETERS. Vos, O.; Kaalen, M. C. A. C. (Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek, Rijswijk, Netherlands). Int. J. Radiat. Biol., 14: 107-18(1968).

The radioprotective effects of cysteamine, glycerol, and dimethyl sulphoxide were investigated at the cellular level. The incidence of anaphase bridges occurring at one hour after irradiation and the length of mitotic delay served as criteria for radiation damage. The data were compared with those on protection against radioinduced loss of reproductive integrity obtained in previously published experiments. It was shown that the protection assessed by any of the three parameters was of the same magnitude. This similarity in response to protection suggested a similarity in the nature of the lesions involved. Damage to the cell membrane, as shown by leakage of haemoglobin and potassium from rat erythrocytes, indicated a different protective capacity of the three compounds. This was most evident with dimethyl sulphoxide, which protected as judged by the three criteria mentioned in the first paragraph, but sensitized with regard to membrane permeability. Since radioinduced mortality of animals was mostly due to a loss of the reproductive integrity of certain stem cells, the value of chemicals with regard to the protection of whole animals could not be assessed on account of their effectiveness in protecting the cell membrane. (auth)

**20285** EFFECTS OF LARGE DOSES OF GAMMA RADIATION ON THE HUMAN EYE. Claus, Hans-Guenther; Diethelm, Lothar; Cullmann, Brigitte (Johannes-Gutenberg-Univ., Mainz). Strahlentherapie, 136: 395-410(Oct. 1968). (In German).

Twenty-six patients with cancer of the nasal cavity and paranasal sinuses were submitted to an intensive telegamma radiotherapy, including the invaded orbita. In almost all patients inflammatory modifications occurred at the ocular bulb and its adnexae. A serious complication was ulcerative keratitis with perforation possibility, the panophthalmia and the secundary glaucoma. Such serious complications often necessitated an enucleation. Cataract was only of secondary importance. It only caused a visual reduction. The atrophy of the nervus opticus confirmed the limited tolerance of the nerve. Because of intensive irradiation of the eye, with all its complications and risks, irradiation should be done only when strictly necessary especially when the opposite eye has a reduced vision. The achieved results justified this therapeutic measure. (auth)

**20286** POSSIBILITIES OF INDIVIDUAL APPLICATION OF STANDARDIZED FOUR-AXIS $^{60}$Co PENDULAR IRRADIATION OF THE SMALL PELVIS. Welker, Klaus (Institut fuer Krebsforschung, Berlin). Strahlentherapie, 136: 420-5(Oct. 1968). (In German).

Pendular irradiation therapy on four axis, for the lower pelvis gave a good isodose distribution in all cases where a high dose should be administered to the parametria, with sparing the tissues between the urinary bladder and the rectum. It was shown that the application of this technique raised no particular problem for the clinical practice. The dose distribution was determined only once and could be transferred to all patients with a mean error of only 5%. The absolute dose, however, at one point should be documented for each patient, to calculate the treatment time. For these calculations, approximation formulas were presented. (auth)

**20287** RADIATION THERAPY OF THE PARAMETRIA IN GYNECOLOGIC TUMORS. Kivinitty, Kalevi; Unnerus, Carl-Erik (Univ., Helsinki). Strahlentherapie, 136: 416-19(Oct. 1968). (In German).

Of the irradiation apparatus at hand in Finland, telecobalt and betatron were the best and most appropriate for radiotherapy of the parametria. Orthovoltage radiations should no longer be used, the attainable depth dose being too low. The best dose distributions were obtained with moving beam therapy, but this required some precision in the set up of the irradiation fields. (auth)

**20288** STUDIES ON THE RESTORATIVE EFFECT OF TAURINE ON LEUKOPENIA INDUCED BY RADIATION THERAPY. Fukuda, Tadashi; Abe, M. (Kyoto Univ.). Nippon Igaku Hoshasen Gakkai Zasshi, 28: 959-66(Oct. 1968). (In Japanese).

This paper concerns the results of a statistically controlled study of the effectiveness of taurines on patients with leukopenia attributable to radiation therapy. Taurine was given to patients during the radiation therapy beginning on the day when the leukocyte count was depressed below 4000 cells/mm$^3$. 750 mg of taurine was delivered orally 4 times a day, 30 minutes after every meal and at bed time. (Total amount of taurine is 3000 mg a day.) During the treatment with taurine, radiation therapy was continued with unchanged doses and neither blood transfusion nor administration with drugs which stimulate haematopoiesis was performed in this period of time. At the same time a study has been made of the effect of radiation therapy on the urinary excretion of aminoacids. More intensive study was made with respect to the relationship between leukocyte counts and excreted taurine amount. By giving 3000 mg of taurine daily the luekocyte counts which were decreased under 4000 cells/mm$^3$ could be increased again, although irradiation was continued with unchanged doses. The therapeutic effect was proven by statistically analyzing the leukocyte counts. It was also demonstrated that the taurine amount excreted into urine was greater in a group in which leukopenia was prominent as compared with a group in which leukopenia was not pronounced due to radiation therapy. (NSA of Japan)

**20289** EXCRETION OF PURINE AND PYRIMIDINE SUBSTANCES IN PATIENTS WITH CANCER PRIOR TO AND AFTER IRRADIATION. Fedorov, N. A.; Bogomazov, M. Ya.; Lapina, G. F.; Abakumova, O. Yu. (Central Postgraduate Medical Inst., Moscow). Vop. Onkol., 14: No. 12, 3-7(1968). (In Russian).

Following localized radiotherapy of pulmonary cancer in five patients, the urinary content of purines and pyrimidines increased by a factor of 1.5 to 2. Chromatography and spectrophotometry were used for determining the contents of desoxycytidine, desoxyuridine, pseudouridine, oxypurine, orthidine, and other substances following 2000 R doses. (H.L.W.)

**20290** EFFECTS OF COMBINED CHEMICAL, RADIATION, AND HORMONAL THERAPY ON HEMATOPOIESIS IN MAMMARY CANCER PATIENTS. Ivanova, T. F. (Leningrad Medical Graduate Inst.). Vop. Onkol., 14: No. 12, 96-7 (1968). (In Russian).

Studies were made on the peripheral blood of mammary cancer patients treated by a combination of drugs, radiation, and hormones. Data indicated that effects on blood were determined by the method of therapy. A combination of gamma radiation and hormones produced variations in the number of leukocytes; changes in leukopoiesis were related to the ratiosensitivity of the individual. Hematopoiesis was inhibited by complex therapy with antiblastomatic preparations. However, the degree of inhibition of hematopoiesis depended on the dose of medication and the time interval between radiation exposure and chemical treatment. (R.V.J.)

**20291** MORE HAZARDS OF RADIATION. New Engl. J. Med., 279: 714-15(Sept. 26, 1968).

Evidence that ionizing radiation is a tumorigenic agent in man is briefly reviewed. Skin cancer, which followed radiation-induced dermatitis and ulceration occurred in early roentgenologists. Osteosarcomas and carcinoma of the paranasal sinuses resulted from ingestion of mesothorium by Ra watch-dial painters. Thyroid tumors, including cancer, have been found in people exposed to fallout and atomic-bomb radiation. There is a high incidence of leukemia in mice after exposure to radiation. Leukemia in the Japanese atomic-bomb victims was found, the incidence being proportional to the dose of radiation above 100 RAD. In mice and rats irradiation produces diverse mammary tumors after single doses and protracted exposure. The response in rats is linear between 25 and 400 RAD, and the yield of tumors is suppressed by ovariectomy. The incidence of mammary tumor is increased by extensive fluoroscopy, and in women who received radiotherapy to a single breast for mastitis, tumors appeared in higher incidence in the irradiated than in the nonirradiated breast. The incidence of tumors in the breasts of females exposed to atomic-bomb radiation at Hiroshima and Nagasaki is increased and, in contrast to nonexposed women, occurs in the premenopausal period. The association between radiation exposure and breast tumors in women has now been suggested in three studies. (BBP)

**20292** HAZARDS OF X-RAY DIAGNOSIS. Naturwiss. Rundsch., 21: 74-5(Feb. 1968). (In German).

Estimated irradiation exposures of the U. S. population are described and discussed. There are $\sim 130 \times 10^6$ medical and dental x-ray studies performed annually in the U. S. At the present rate of diagnostic x irradiations there may be ~3000 to 30,000 annual fatalities because of cumulative irradiation effects, including 350 to 1100 due to leukemia, 55 to 440 due to thyroid cancer, 170 to 550 due to bone cancer, and 1000 due to the general effect of radiation on human life expectation. However, radiation effects would

be most apparent in coming generations because of genetic effects. Malformations and impairments could cause from 2000 to 26,000 deaths annually. Artificially produced radiation which now causes ~½ of the total natural radiation adds up to 55 Rem annually for each American, with 90% arising from diagnostic x radiation. Because of differences in equipment and methods, a single thoracic x-ray study can deliver up to 1000 mRem. In fluoroscopy the irradiation dose is from 5 to 400 mRem. The main factors that cause excessive irradiation are defective techniques, antiquated equipment, inattention to radiation protection, inadequate training, and excessive exposures because of poor film or poor film development. Improved shielding of equipment often can reduce exposure hazards by 10-fold. (BBB)

**20293** MORPHOLOGY OF RADIATION-INDUCED HEART DISEASE. Fajardo, Luis F.; Stewart, J. Robert; Cohn, Keith E. (Stanford Medical School, Palo Alto, Calif.). Arch. Pathol., 86: 512-19(Nov. 1968).

The morphological alterations in the heart or pericardium of 16 patients who developed heart disease after irradiation to the mediastinum are reported. For 11 of these 16 cases the clinical features, radiation techniques, and incidence calculations were published previously. The radiation therapy was fractionated in each case, usually 1100 rad/week with no instances of massive individual fractions. One case had several courses over a 4-yr period, and four cases had two courses separated by 9 to 14 months. Connective tissue proliferation was the predominant change in these late radiation lesions located in the heart. Organizing pericarditis with extensive fibrosis was the most frequent alteration and was often reflected clinically by tamponade or pericardial constriction. Diffuse interstitial myocardial fibrosis was commonly present, whereas endocardial and vascular changes were much less frequent. The diffuse nature of the myocardial fibrosis made it difficult to detect grossly, and pathologists should be aware of its deceivingly innocent appearance. The myocardial lesions produced in rabbits were qualitat'vely identical to those observed in humans, but more severe. (BBB)

**20294** $^{59}$Fe LOSS IN STOOL IN VARIOUS HEMATOLOGICAL DISORDERS. Miura, Takeo (Nagoya Univ., Japan). Nippon Igaku Hoshasen Gakki Zasshi, 28: 1288-95(Dec. 1968). (In Japanese).

After the intravenous injection of $^{59}$Fe to patients with hematological disorders, the mode of loss of $^{59}$Fe in stool was observed by plotting the amount of daily $^{59}$Fe loss in stool cumulatively. Normal cumulative $^{59}$Fe loss curve in stool showed two slopes, one a steep curve up to 10 days, and the other a flat curve thereafter. Gastrointestinal bleeding was indicated by a straight cumulative radioiron loss curve in stool. Most iron deficiency anemia cases had a large amount of blood loss in the gastrointestinal tract. A longer continuous first slope and the increase of the total amount of $^{59}$Fe excretion in this period are suggestive of poor radioiron utilization such as hemosiderosis, hemochromatosis and hypoplasia (aplasia). In the patient with hypoplasia or aplasia, a small amount of $^{59}$Fe excretion due to the exfoliation of the gastrointestinal mucous epithelia was thought to exist continously due to increased radioiron exchange between plasma and storage. The patterns of these cumulative $^{59}$Fe loss curve are characteristic in various hematological disorders. Therefore this examination is useful not only for the diagnosis of various hematological disorders but also for the treatment of iron deficiency anemia and hemosiderosis. (auth)

**20295** THE COMPARISON OF CONFORMATION, ROTATION, AND TWO OPPOSITE RADIOTHERAPY REGARDING TO VOLUME DOSE AND INTEGRAL DAMAGE DEFINITION OF INTEGRAL DAMAGE. Hattori, Hiroyuki (Aichi Cancer Center, Japan). Nippon Igaku Hoshasen Gakki Zasshi, 28: 1240-4(Dec. 1968). (In Japanese).

Integral Damage (I. Da.), a new indicator of degree of concentration of radiation is defined, presenting the idea of dose volume with the non lineality relation of dose to damage. The (I. Da.) is calculated by combination of the dose-damage curve S(D) with dose volume. Four types of S(D) were assumed. For these S(D), (I. Da.) given with conformation, rotation and two opposite treatment for uterine cancer were determined experimentally using 6 MeV Linear Accelerator x rays. The value of (I. Da.) ratio of rotation or two opposite to conformation treatment makes it possible quantitatively to compare usefulness of the degree of conformation to other methods. (auth) (TSS)

**20296** RESPIRATORY USE OF $C_2H_5$ $^{131}$I SINCE 1951 AND OF $^{133}$Xe SINCE 1955 IN THE CLINIC OF THE AUTHOR. DIMINUTION OF BIOLOGICAL HALF LIFE TIME. Knipping, H. W. (American Coll. of Chest Physicians, Cologne). Atomkernenergie, 14: 129-36(Mar.-Apr. 1969). (In German).

$^{133}$Xenon has an unusual and favorable biological half-life, if the blood is saturated with inhaled inactive xenon before recording global and regional ventilation, by help of $^{133}$Xe. For regional perfusion control $C_2H_5$ $^{131}$I with a high absorption in blood is proposed specially for the very important synchronous registration of perfusion and ventilation. The synchronous use of $^{133}$Xe and $C_2H_5$ is preferred. Isotope angiocardiography and isotope control of regional ventilation and perfusion avoid the considerable quantity of contrast-material in contrast x-ray analyses. $^{133}$Xe and $C_2H_5$ $^{131}$I are applicable without catheter and puncture. Some old methods of pre-operative examination were a kind of medieval torture, patients did not like them and therefore did not come early and often enough for early diagnosis of bronchial cancer. That is the reason for introducing $^{133}$Xe. Without blocking blood by inactive xenon a sufficient amount of $^{133}$Xe can be brought to the periphery for circulation control, e.g., into the legs without puncture. For isotope aortography and arteriography in this report $C_2H_5$ $^{131}$I is proposed (small doses of $C_2H_5$ $^{131}$I, almost free of inactive $C_2H_5$ $^{131}$I). For optimal economy of radioactivity, introduced via the lungs, it is necessary to know exactly the residual air of patients and to know the thoracal state of rest with help of He/$H_2$ methods and of elegant spirographical technique. N/$O_2$ methods proved not to be exact for this purpose in old cardiac cases (faults caused by the method influencing the arterial deficits). Some variations of the spirographic device specially for maximal economy of introduced radioactivity, for checking $^{133}$Xe retention after intravenous introduction, for manipulating a little cloud of $^{133}$Xe at the beginning of isotope-bronchography and for endothoracal regional pressure-analysis by $^{133}$Xe are proposed. A report on clinical results of early diagnosis of bronchial cancer and cardiac cases is presented. (auth)

**20297** RENAL CLEARANCE IN MAN OF PHARMACEUTICALS CONTAINING RADIOACTIVE IODINE, INFLUENCE OF PLASMA BINDING. Maher, Frank T.; Tauxe, W. Newlon (Mayo Clinic, Rochester, Minn. Mayo Foundation, Rochester, Minn.). J. Amer. Med. Ass., 207: 97-104(Jan. 6, 1969)

Renal clearances of diatrizoate sodium $^{125}$I or iothalamate sodium $^{125}$I measure 90 to 100% of simultaneous classic clearances of inulin; clearances of iodohippurate sodium $^{131}$I or iodopyracet $^{131}$I are 84 and 79%, respectively, of simultaneous clearances of aminohippurate sodium. Plasma binding (8 to 27% of diatrizoate sodium $^{125}$I or iothalamate sodium $^{125}$I 64 to 70% of iodohippurate sodium $^{131}$I; 29 to 42% of iodopyracet $^{131}$I; 7 to 25% of aminohippurate) is revealed by ultrafiltration studies. Binding is labile and dissociable. Correcting clearances of diatrizoate sodium $^{125}$I or iothalamate sodium $^{125}$I for plasma binding yields values exceeding those of inulin clearances. Uncorrected, they are satisfactory substitutes for inulin clearance in man. Clearances of iodohippurate sodium $^{131}$I or iodopyracet $^{131}$I approximate adequately clearances of aminohippurate when carrier iodopyracet is added and the clearances are corrected for plasma binding to provide an estimate of total clearance. (auth)

**20298** CHEMICAL RADIOPROTECTION OF MAMMALIAN CHROMOSOMES IN VIVO: RADIOPROTECTION OF RAT BONE-MARROW CHROMOSOMES WITH A SINGLE PROPHYLACTIC DOSE OF AET. Chaudhuri, Jyoti P.; Langendorff, Hanns (Univ., Freiburg, i. B.). Int. J. Radiat. Biol., 14: 463-7(Dec. 1968).

Of three prophylactic doses of AET pre-treatment 240 mg/kg gave the best protection against chromosome aberrations induced by 640 R of x rays in rat bone marrow, DRF values being 1.23 to 1.36. Even this low DRF at the level of early cellular lesion might considerably increase the survival of sublethally irradiated animals. (auth)

**20299** RADIOPROTECTIVES AND THE GASTROINTESTINAL SYNDROME. Maisin, J. R. (Centre d'Etude de l'Energie Nucleaire, Mol, Belgium). Med. Hyg., 26: 86-90(Jan. 31, 1968). (In French).

The action of ionizing radiations on the digestive tract and, in particular, on the small intestine of the mouse is considered. Also the ways in which the radioprotective substances modify the lesions induced by the radiations are described. (J.F.P.)

**20300** RADIOPHARMACEUTICALS. Bruno, Gerald A. (Squibb Inst. for Medical Research, New Brunswick, N. J.). Bull. Parenter. Drug. Ass., 22: 234-7(Sept.-Oct. 1968).

The production and testing of radioisotopes for medical diagnostic and therapeutic purposes are reviewed, along with safety features employed. The large radiopharmaceutical production facility described was the first structure designed and built for the sole purpose of preparing radiopharmaceutical products. The building was designed in accordance with Atomic Energy Commission requirements for the safe-handling of radioisotopes. Airborne radioactive contamination in the building is controlled by a one-pass nonrecirculating ventilation system. The potentially con-

taminated air that is exhausted from the building is passed through banks of charcoal and electrostatic precipitron filters. The efficiency of the filtration system is continuously monitored by a radiation detector that is located beyond the filters in the ventilation system. When large amounts of radioactivity are delivered to the manufacturing site from various nuclear reactors around the country, the first step in processing involves the use of high-level caves or hot cells. These elaborately shielded facilities are used for subdividing the radioactivity to levels that can be handled without the use of remote control equipment. The hot cells and their use are described in detail. Tests for radiochemical potency, radiochemical purity, sterility, pyrogenicity, and safety conducted on the radiopharmaceuticals are also mentioned. Development and use of radioisotope generators, which provide a practical means for utilizing extremely short half-life radioisotopes in routine clinical practice, are considered. (BBB)

**20301** IRREGULARITY OF ISODOSE DISTRIBUTION IN TELECOBALT CONFORMATION RADIOTHERAPY. Ueda, Toshio; Kitabatake, Takashi (Aichi Cancer Center Hospital, Japan). Nippon Igaku Hoshasen Gakkai Zasshi, 28: 58-63(Apr. 1968). (In Japanese).

The shape of expected target volume and measured isodose contours of 90% area were compared and discussed in conformation radiotherapy unit RI-156. The beam shaper system was attached to this machine. The parameters considered were minor axis of oval cams. The ratio of major axis and minor axis of oval cams were $^5/_4$, $^5/_3$, $^5/_2$, and $^5/_1$. Those oval expected target volumes were geometrically analyzed, and iso-time curves were drawn. The larger the ratio of major axis/minor axis of expected target volume the larger the magnitude in strain of dose distribution. (auth)

**20302** LOSS OF THORIUM DAUGHTER BY THORIUM DIOXIDE PATIENTS. Hursh, John B. (Univ. of Rochester, N. Y.). Ann. N. Y. Acad. Sci., 145: 634-41(Dec. 11, 1967). (UR-49-912).

The loss of members of the thorium series by excretion from man is discussed in detail. Estimates of the excretion of a particular Th-daughter product may be made in either of two ways; collection of excreta and direct measurement of the body loss, and tissue or whole-body analysis yielding the ratio of the daughter to its immediate parent at a postinjection time sufficiently long so that the ratio is in a steady state. A special detector is described for determining the fraction of $^{220}$Rn formed as a daughter from $^{224}$Ra and lost in expired air in thorotrast-injected patients. Due to very low excretion rates of $^{212}$Pb and appreciable washout of $^{212}$Pb from the liver and spleen as indicated by tissue measurements, it is assumed that both thoron and $^{212}$Pb move from the site of principal thorotrast deposit. (B.L.M.)

**20303** OBLIQUE INCIDENCE CORRECTIONS IN THE $^{60}$Co TELETHERAPY. Dworakowski, M.; Majenka, I.; Gwiazdowski, B. (Inst. of Oncology, Warsaw). Post. Fiz. Med., No. 1, 11-17 (1967). (In Polish).

A study aimed at determining the corrections which take into account the changes in the isodose distributions in the applications of Co-60 teletherapy is reported. The isodose distribution measurements were made on a water phantom for 8 × 8, 10 × 8, and 10 × 10 cm fields at the beam incidence angles of 10°, 20°, and 30°. The experimental curves were compared with those obtained graphically from isodose charts shift of $^1/_3$, $^1/_2$ and $^2/_5$. For practical purpose the $^1/_2$ shift was adopted for beam incidence angles less than 20° and that of $^2/_3$ for angle 20° and greater, for the above range of field sizes. (auth) (NSA of Poland)

**20304** ESTIMATION OF TUMOR DOSE IN CONFORMATION RADIOTHERAPY. Okumura, Yutaka. Tohoku J. Exp. Med., 95: 359-68(Aug. 1968).

Dosage estimation for conformation radiotherapy applied to cervical cancer was discussed. Field size and shape in conformation therapy was freely changeable according to the shape and size of tumor. When the same size and shape of the field for therapy by Co-60 gamma ray was applied to each case, tissue-air ratio TAR was given by an equation, $T = -0.00326d + 1.035$, where T is TAR and d an average depth. The concept of tissue-air ratio could not be applied to dose calculation in moving field radiotherapy by 6 MV x-rays, because the quality of x-rays emitted from a linear accelerator is rather different from that of γ-rays of the telecobalt unit. Therefore, the tissue-reference output ratio was defined instead of tissue-air ratio in the form of: Tissue-reference output ratio = −(Tissue dose/Output in a field of 10 × 10 cm). The output in a field size of 10 × 10 cm is presented in the monitor chamber which is watched during operation. When the conformation radiotherapy was applied to 20 cases of uterine cancer with fields of the same size and shape, tissue-reference output ratio R was given by an equation $R = -0.0026\,d + 1.048$ where d is the average depth. The difference of calculated dose from measured one using a Mix D phantom was 3%, and the error is negligible in clinical practice. (auth) (NSA of Japan)

**20305** CONSIDERATIONS ON METHODS OF CONSTRUCTING ISODOSE CURVES FROM MINIMUM EXPERIMENTAL DATA. 3. DOSE DISTRIBUTION IN THE THORAX IN 4.3 MV X-RAY THERAPY. Onai, Yoshio; Tomaru, Teizo (Cancer Inst., Tokyo). Nippon Igaku Hoshasen Gakkai Zasshi, 27: 1480-93(Feb. 1968).

Several methods of correcting the standard isodose curves for air-filled lungs have been described in the literature. The methods of calculation of the dose distribution point by point are considered to find a less laborious procedure in manual dose planning and to derive an empirical formula for the computer dose planning in the treatment of thoracic lesions with 4.3 MV linac x rays. Analyses were made of the results of measurements with nonuniform phantoms. From the comparisons with the dose distributions obtained by the application of published correction methods for $^{60}$Co γ-rays to 4.3 MV x rays, the following correction methods may be recommended: (1) The correction factor (that is, actual/water phantom dose) can be expressed as S. $\exp\{\mu_e l\ (1-\rho)\}$ where S is the scatter correction factor, $\mu_e$ is the effective absorption coefficient in water, l is the passed thickness of the air-filled lung, and $\rho$ is the average density of the air-filled lung. In general the scatter correction factor S may be expressed as $S = k\{1 - (B/B + C)/(e^{-0.28t} - e^{-0.28(l+t)})\}$ where t is the depth in water-equivalent tissue beyond the lung. When t = 0, k is B + C and when t > 0, k is unity. B and C are given by $B = 0.138 - 0.243\rho + 0.105\rho^2$ and $C = 0.837 + 0.2594\rho - 0.0964\rho^2$. But in clinical practice, it is probably sufficient to use 0.95 as the scatter correction factor since the values of S may range from 1.0 to 0.9 for the points both in and beyond the lung for 4.3 MV x rays. The effective absorption coefficient can be expressed as $\mu_e = 0.0656 - 0.011 \log A$ where A is the field size at the surface. These formulae are useful for calculating the doses in the thorax by the computer. (2) In manual dose planning, the graphical method may be preferable to the other methods because of the simplicity with which it can be applied in practice. This has been pointed out already by Greene et al. and Sundbom. For 4.3 MV linac x rays, the graphical method, in which the isodose line obtained in a water phantom is moved distally by 0.5 times the thickness of the lung, can be applied for the points both in and beyond the lung provided that the passed thickness of the lung is less than 10 cm and that the average density of the lung ranges from 0.35 to 0.2 g/cm$^3$. This method can be applied for $^{60}$Co γ-rays provided that the source-surface distance is longer than 50 cm. (3) The method devised by Batho, which calculates the correction factor on the basis of the tissue-air ratio, seems to be relatively accurate and also may be useful for computer dose planning. (auth) (NSA of Japan)

**20306** DISPLACEMENT APPLIANCES IN RADIOTHERAPY. Markwell, B. D.; Whittle, R. J. M. (St. Bartholomew's Hospital, London). Brit. Dent. J., 124: 564-8(June 18, 1968).

Methods of protecting healthy oral tissues during irradiation of tumors of the face and jaw are described. Lead mounted on a stand can be introduced into the beam to protect any selected area, and in practice this method is frequently used. The application of lead to an intra-oral prosthesis is an elaboration of this technique. The disadvantage of this prosthesis is in the weight of the lead required to ensure adequate protection from a $^{60}$Co teletherapy beam. A patient will not tolerate a prosthesis heavily loaded with lead because of its weight, and the excessive bulk makes its design difficult. An alternative approach to the problem is to displace normal tissues out of the beam. It is no longer feasible to use a 250-kV x-ray unit to treat a carcinoma in the oral cavity because the incidence of bone necrosis is higher than with $^{60}$Co, the mandible may shield the tumor, and the unpleasant features of a desquamating skin reaction will be super-imposed. Displacement of the following structures is considered: (1) The mandible, floor of mouth, and tongue (in one block) – downward displacement. (2) The tongue — (a) forward displacement: (b) lateral displacement. (3) The lips — forward displacement. Construction and use of prostheses for protecting these structures are described. (BBB)

**20307** DOSAGE CALCULATION FOR CONFORMATION RADIOTHERAPY BY 6 MV X-RAYS. Okumura, Yutaka (Aichi Cancer Center, Japan). Nippon Igaku Hoshasen Gakkai Zasshi, 27: 1596-1600(Mar. 1968). (In Japanese).

The concept of tissue-air ratio could not be applied for dose calculation in moving field radiotherapy by 6 MV x rays, because the quality of x rays emitted from a linear accelerator is much different from γ rays from a telecobalt unit. Therefore the tissue-reference output ratio was defined instead of the tissue-air ratio, that is, Tissue-Reference Output Ratio = (Tissue Dose/Output in Field 10 cm × 10 cm). The output in a field 10 cm × 10 cm is represented in the monitor chamber reader and it is watched during

operation. The tissue-reference output ratios in fields 4 cm × 4 cm to 16 cm × 16 cm were calculated following the definition. When the conformation radiotherapy was applied to 20 cases of uterine cancer with same size and shaped field, tissue-reference output ratio (T) was given by an equation $T = -0.0026\,\bar{d} + 1.048$ where $\bar{d}$ is average depth. (auth) (NSA of Japan)

**20308** GONAD PROTECTION WITH PELVIC X-RAY PHOTOGRAPHS. Schulze, K. J. (Medizinische Akademie, Dresden). Beitr. Orthop. Traumatol., 13: 689-92(Nov. 1966). (In German).

Various configurations of radioprotective shields for the gonads are indicated and discussed. Apart from a few atypical views there are no difficulties in close-up shielding of the testis. Capsules constructed of Pb with a Pb equivalent value of 1 mm, fastened to the body with an adjustable plastic belt have been used satisfactorily, without interfering with the x-ray picture. However, because the topography of the ovaries varies with age, it is difficult to provide close-up shielding for these organs. The younger a child is, the more laterally the ovaries are situated. Only in the second or third yr are the ovaries located in the true pelvis, close to the midline. In order definitely to shield the ovaries within the small and large pelvis, a close-up shield should extend to the symphysis so that any anomalous position of the ovaries will be shielded. In order to shield against both stray and direct irradiation the shield should extend around the body. A shield made of Pb rubber with 1-mm Pb equivalent that extends over the symphysis, but not the hip joints is adequate. The shield is placed over the abdomen so that the upper anterior iliac spine is covered. Legal requirements to make the physician and other medical personnel responsible for providing adequate shielding of the gonads should be enacted. (BBB)

**20309** CONSIDERATIONS ON METHODS OF CONSTRUCTING ISODOSE CURVES FROM MINIMUM EXPERIMENTAL DATA. REPORT I. STANDARD ISODOSE CURVES FOR RECTANGULAR FIELDS IN COBALT TELETHERAPY. Onai, Yoshio; Tomaru, Teizo (Japan Foundation for Cancer Research, Tokyo). Nippon Igaku Hoshasen Gakkai Zasshi, 27: 1323-38(Jan. 1968). (In Japanese).

Dose calculation methods described in the literature were reinvestigated experimentally and theoretically to obtain the simple method of calculating isodose curves for rectangular fields. The results were as follows. 1. When the field size is defined as the area bounded by the line in air at the edge of the beam corresponding to 50 percent of the central axis dose, the effect of penumbra on the central axis depth dose can be ignored in the range 0.8–4.0 cm of geometrical penumbra at the surface. The field size defined as above is also close to the area bounded by the line in tissue at the edge of the beam corresponding to 50–60 percent of the central axis dose at all depths. 2. The central axis depth doses converted from $F^{1-m}$ (Pfalzner's equation) using the depth doses for SSD 50 cm as a standard agreed with experimental data within the errors of ±5% for any field and depth, provided that the source to surface distance ranged from 35 to 100 cm. Calculated values of $F^{1-m}$ are given. 3. The area reduction factors for Co-60 γ-rays were obtained from the values of scatter dose calculated by Clarkson's method. Percentage depth doses calculated using these area reduction factors were in good agreement with the data obtained from the equivalent area at conventional x-ray qualities analyzed by Jones and Day. Analyzing these data and Sterling's method, it was found that the area reduction factor $F_r$ is given by $F_r \doteqdot 4\,E/(1+E)^2$, where E is elongation ratio. 4. The square field isodose crossplots method used by Evans may be most simple and speedy to calculate depth doses for points off the central axis without computer, especially for points in the penumbral region. However, when this method is applied to elongated field the errors may increase significantly in the regions outside the 15% isodose curve. In this case, it may be useful to apply the corrections derived from the concept of equivalent area to the data of square field isodose crossplots. The isodose points off central axis in the region of full irradiation by the Co-60 source can be obtained by shifting the isodose point on the central axis using the curves indicated, which is applicable to any elongated field. (auth) (NSA of Japan)

**20310** INTRACAVITARY RADIUM: A FLUOROSCOPIC TECHNIQUE OF INSERTION AND A NEW INSTRUMENT. Van Voorhis, Lee W.; Fuller, Dale E. (Univ. of Iowa Hospitals, Iowa City). Amer. J. Obstet. Gynecol., 102: 521-4(Oct. 15, 1968).

A technique for Ra treatment of endometrial carcinoma was developed which reduces Ra handling time and exposure to operators. A portable fluoroscope with an image intensifier was used in the operating room to improve the accuracy and safety of Ra insertion. A foot switch controlled by the operator conveniently allowed visual confirmation of Ra distribution as projected on the television screen at any point in the procedure. Dosimetric studies indicated the desirability of placing a Ra capsule transversely at the top of the fundus. Fluoroscopic control made this maneuver a relatively simple procedure. The radiation exposure to the patient from the fluoroscope in this procedure is 5.0 R/min to the anterior abdominal skin and is considered insignificant in this therapeutic situation. Additional radiation exposure to personnel was determined by measuring scattered x-ray exposure during fluoroscopy at a 1 m radius from a phantom representing the patient. Exposure due to scatter ranged from 6 to 40 mR/min depending upon distance and relation to the axis of the x-ray beam. On the basis of these findings the following rules for personnel protection were established: personnel required to be within 1 m of the collimator should wear lead aprons; unshielded hands should be kept out of the direct beam; and maximum exposure for unprotected surfaces is 50 sec/month or 600 sec/yr. (BBB)

**20311** CONSIDERATIONS ON METHODS OF CONSTRUCTING ISODOSE CURVES FROM MINIMUM EXPERIMENTAL DATA. REPORT 2. DOSE DISTRIBUTION FOR OBLIQUE INCIDENCE IN COBALT TELETHERAPY. Onai, Yoshio; Irifune, Toraji (Japan Foundation for Cancer Research, Tokyo). Nippon Igaku Hoshasen Gakkai Zasshi, 27: 1339-46(Jan. 1968). (In Japanese).

Methods of deriving an isodose curve for oblique incidence from normal isodose curve have been reported by several workers. These are: the effective SSD method; the effective attenuation method; which includes the Exp (±μh) method, the method by correction factor per unit length, the approximate formula by Murison and Hughes, and the tissue air ratio method; and the isodose curve shift method. In these methods, the isodose curve shift method may be the simplest one. According to the formula by Murison and Hughes, the oblique isodose angle depends on SSD, the effective attenuation coefficient and depth, besides the angle of incidence. It will be necessary, therefore, to vary the distance of shifting the normal isodose curve with these conditions. Considerations on this problem were made experimentally and theoretically. From the results of comparing the values obtained by three methods, which are the effective SSD method, the Murison and Hughes' formula and the tissue air ratio method, with measured values, it was found that the values by Murison and Hughes' formula, in which the effective attenuation coefficient calculated for each SSD, field size and depth was used, gave the best agreement with measured values. Consequently, by analyzing the oblique isodose angle calculated by this formula it will be possible to obtain the reasonable shift method. The results of this analysis are shown, comparing with the shift methods of $\frac{1}{3}h$, $\frac{1}{2}2h$ and $\frac{2}{3}h$. In clinical practice it may be recommended to use the shift indicated to correct for the oblique incidence. (auth) (NSA of Japan)

**20312** MEASUREMENTS OF INTEGRAL DOSE IN THE $^{60}$Co TELETHERAPY USING LEUCO TRIARYLMETHANE DOSIMETER SOLUTION. Okajima, Shunzo; Hakariya, Satom (Nagasaki Univ.). Nippon Igaku Hoshasen Gakkai Zasshi, 28: 64-7(Apr. 1968). (In Japanese).

Leuco triarylmethane compound dosimeter solution was used to the measurement of the integral dose in the Co-60 teletherapy. Experiments were made with water phantoms. Results obtained are as follows: (1) The integral dose is found to be in direct proportion to the entrance field area, (2) The source-surface distance has practically no effect on the integral dose, (3) In the case of small-diameter cylindrical phantoms, the integral dose is small, because a large amount of scattered radiation escapes from the side surface. However, if the diameter of the phantom is larger than that of the direct beam by several centimeters, the integral dose becomes saturated. (4) The relationship between the specific integral dose and the depth of the body from the surface was obtained by measurement. By multiplying the dose irradiated to a field by the area of that field and by the specific integral dose obtained from the curve, a correct integral dose can be obtained easily. (auth) (NSA of Japan)

**20313** ISODOSE DISTRIBUTIONS IN PARAXIAL PLANES IN $^{60}$Co RADIATION BEAMS. Gwiazdowski, B.; Dzikiewicz, H. (Inst. of Oncology, Warsaw). Post. Fiz. Med., No. 1, 19-27 (1967).

The depth dose distributions are the basis of contemporary radiotherapy. They are generally presented as percentage of the dose at maximum in the central axis of the beam. Isodose distribution charts for routine use in the planning of treatment are usually prepared for principal planes of the beam, which include the central axis and consist of the main planes of symmetry of the beam. The isodoses in principal planes, however, do not offer full information about space distribution of the dose. It is not too difficult to obtain complete isodose distribution in paraxial planes for circular fields, by means of geometrical methods. For rectangular field the problem becomes more involved, because the dose

at the edge of the beam depends on many factors and there is no full symmetry in the cross section of the beam. Therefore the paraxial distributions must be determined from measurements. At the Institute of Oncology in Warsaw the problem was investigated by obtaining at least an approximate picture of the full spatial dose distribution using a Co-60 teletherapy unit employing rectangular fields. (auth) (NSA of Japan)

**20314** CALCULATION OF DOSE DISTRIBUTIONS IN RADIATION THERAPY BY A DIGITAL COMPUTER. 1. THE COMPUTATION OF DOSE DISTRIBUTIONS IN A HOMOGENEOUS BODY FOR $^{60}$Co γ-RAYS AND 4.3 MV X-RAYS. Onai, Yoshio (Japan Foundation for Cancer Research, Tokyo); Konishi, Keisuke. Nippon Igaku Hoshasen Gakkai Zasshi, 27: 653-66(Sept. 1967). (In Japanese).

A mathematical expression is presented for approximating the dose distributions in rectangular beams of $^{60}$Co γ-rays and 4.3 MV x rays in a water equivalent medium. This equation, supported by experimental results, may be used for any field, any SSD, and any oblique field, and can be used to print out the combined multi-field isodose curves directly with small error. Examples of the computer print-out of a single field, oblique field, two opposing pairs, 120-deg. arc, and tangential rotation were shown. (auth) (NSA of Japan)

## Radiation Effects on Animals

*Refer also to abstracts 19884, 20113, 20115, 20162, 20260, and 20284.*

**20315** (BNL-50058) RECOVERY AND REPAIR MECHANISMS IN RADIOBIOLOGY. Report of Symposium held June 5-7, 1967. Brookhaven Symposia in Biology Number 20. (Brookhaven National Lab., Upton, N. Y.). 325p. (CONF-670632). Dep. CFSTI.

Abstracts of fourteen of the sixteen papers presented at this symposium were prepared for inclusion in NSA. Two papers have appeared previously in NSA. The purpose of the symposium was to examine the concept of radiation recovery at various levels of biological organization. (C.O.)

*For abstracts of individual papers see: 20079, 20147-20150, 20260-20263, 20316, 20341-20343, and 20439.*

**20316** (BNL-50058, pp 161-8) STEM CELL FUNCTION RELATED TO THE REPAIR OF RADIATION DAMAGE. Till, J. E.; McCulloch, E. A. (Toronto Univ. (Ontario). Ontario Cancer Inst., Toronto).

Recent findings concerning the regulation of the proliferation and differentiation of colony-forming units (CFU) in hematopoietic tissues are presented; an attempt to relate these findings to the repair of radiation damage in the hematopoietic system is made. Discussions are presented on evidence that CFUs are hematopoietic stem cells and therefore factors in the control of animal survival; genetically determined control mechanisms that affect survival (genotype in relation to radiosensitivity of stem cells); effects of bacterial endotoxin on stem-cell proliferation; and other factors, such as environment and physiological pathways expected to influence survival. It was concluded that in the future, a comprehensive model of the relation between effects of radiation at the cellular levels and effects on animal survival must take these factors into account. (C.O.)

**20317** (CEA-R-3676) RESEARCH TRENDS IN RADIOBIOLOGY SINCE 40 YEARS. A NEW APPROACH: THE ENZYMATIC REPAIR FUNCTION OF DNA, INTERNAL FACTOR IN EVOLUTION OF BIOLOGICAL SYSTEMS UNDER IRRADIATION. Mouton, Robert (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Dec. 1968. 74p. (In French). Dep.

An historical scheme of successive research working hypotheses in radiobiology since 1924 was first presented. Less than a generation ago the effects of radiation exposure were viewed as being direct, immediate, irreparable and unmodifiable. Now it is generally accepted that radiation lesion can also be indirect, delayed, reparable and often modified with appropriate chemical or biochemical treatment. It was however in 1962 to 1964 that came the decisive breakthrough in radiobiology with the discovery that the cell possesses a natural active self-defense mechanism against whatever stress would affect the integrity of the genetic message contained in the DNA structure itself. The existence of what could be considered as a fourth DNA function, i.e., self-repair by enzymatic action under genetic control-brings at least to radiobiology the missing molecular biology basis it needed to get out of its phenomenological night after abandon of the generalization of Lea's theory through lack of experimental evidence. Secondly, an enlarged synthesis was presented considering the possible role of DNA repair system not only in cell survival-in presence or absence of dose modifiers or mutagens-but also in the artificial and natural evolution of biological systems exposed to sub-lethal doses of radiation. Most recent data from the literature fit well with what must be still considered as a general working hypothesis. Studies dealing with phenotypic and genotypic characters linked with the acquisition of γ and UV radiation resistance in Escherichia coli K12 have been started.

**20318** THE EFFECT OF RADIATION ON EHRLICH ASCITES TUMOR CELLS. PART 2. EFFECTS OF $^{60}$Co GAMMA RAY, 29 MV X-RAY AND 29 MeV ELECTRON ON CELL NUCLEI OF ASCITES TUMOR CELLS. Yoshikubo, Kunihiko (Jikei Univ., Japan). Nippon Igaku Hoshasen Gakkai Zasshi, 28: 89-97(Apr. 1968). (In Japanese).

Data obtained with hyperdiploid Ehrlich ascites tumor exposed to $^{60}$Co γ ray, 29 MV x ray, and 29 MeV electrons, were compared with regard to changes of mitotic rate, micronuclei, polynuclei and aberrations of anaphasic cells. The mitotic rate, micronuclei, and aberrations of anaphasic cells after irradiation indicated differences among the three types of radiation, however, no difference in polynuclei was seen. Numerical relations for the changes after irradiation were determined. When the basis of $^{60}$Co is one, the 29 MV x ray was 0.87, and 29 MeV electron was 0.92 in mitotic rate. In micronuclei 29 MV x ray was 0.60 and 29 MeV electron was 0.62. In polynuclei 29 MV x ray was 1.0 and 29 MeV electron was 0.95. In damaged cells of anaphase 29 MV x ray was 0.85 and 29 MeV electron was 0.88. In chromosome bridges 29 MV x ray was 0.78 and 29 MeV electron was 0.81. In lagging chromosomes 29 MV x ray was 0.59 and 29 MeV electron was 0.58. $^{60}$Co gamma ray was the most effective for these changes, but no difference between 29 MV x ray and 29 MeV electrons were noted. (NSA of Japan) (TSS)

**20319** THE EFFECT OF RADIATION ON EHRLICH ASCITES TUMOR CELLS. PART I. RELATIONSHIP BETWEEN CHROMOSOME PLOIDY AND RADIOSENSITIVITY IN METASTASIZED TUMOR CELLS. Yoshikubo, Kunihiko (Jikei Univ., Japan). Nippon Igaku Hoshasen Gakkai Zasshi, 28: 72-88(Apr. 1968). (In Japanese).

The radiosensitivity of hyperdiploid and polyploid primary or metastatic tumor cells was studied. It was found that after irradiation the metastatic tumor cells were more radiosensitive than primary tumor cells. The frequency of chromosome breaks, lagging chromosomes and chromosome bridges per cell was found to be approximately proportional to the chromosome number, while frequency per chromosome was the same. The frequency of cells with micronuclei in metastatic tumor cells was higher than primary tumor cells in number. The frequency of polynuclei was higher in irradiated tumor cells than immediately before irradiation, however, there was no difference between the primary and metastatic tumor cells. The polyploid cells were more sensitive than hyperploid cells to x irradiation. (NSA of Japan) (TSS)

**20320** OBSERVATIONS ON THE LETHAL EFFECT OF X RAYS OF DIFFERENT HARDNESS ON THE PUPA OF MUSCA DOMESTICA L. Rubini, P. G.; Caprotti, M. (Univ., Pavia, Italy). Symp. Genet. Biol. Ital., 13: 387-92(Oct. 1966). (In Italian).

Studies were conducted on the mortality of housefly pupae exposed to x rays of different energy. The lethal effect was found to be greater for hard x rays (230-KV radiation filtered by 5 mm Al) than for 80-KV unfiltered softer rays. Equal doses of x rays of 80, 70, and 10 KV caused, respectively, 86, 88, and 37% mortality among pupae of the same age. Equal doses (20,000 R) obtained at a constant voltage (80 KV) with filtration through 0.01, 0.1, 0.3, and 1.0 mm Al caused mortality to increase with x ray hardness, from 48 to 88%. These results disagree with general experience with RBE values of ionizing radiations of different energy levels, and appear to be due to intrinsic properties of the material tested. (BBB)

**20321** EFFECT OF GAMMA RAYS ON THE PROTEOLYTIC ACTIVITY OF "IN VITRO" IRRADIATED BLOOD CELLS. III. EFFECT ON TOTAL LEUCOCYTES. Kopitar, Majda; Cotic, Vladimir; Turk, Vito; Lebez, Drago (Jozef Stefan Nuclear Inst., Ljubljana, Yugoslovia). Strahlentherapie, 136: 621-5(Nov. 1968).

Peripheral leucocytes, isolated by the method of Skoog and Beck, were irradiated in vitro at 37°C in a suspension of 50% rabbit serum and Hanks buffer (pH 7.4). The nitrogen value for a lymphocyte supernatant (300,000 gmin) of $10^7$ lymphocytes was determined = 50.0 γ of N. The value of nitrogen supernatant for the mixture of $10^7$ leucocytes (71% lymphocytes + 29% PMN) was determined, on the basis of the known values of each individual type of leucocyte cells. The nitrogen value was 65.5 γ of N. The

proteolytic activity of pure leucocytes (control and irradiated) was investigated. The effect of doses of 200 to 1200 R gamma irradiation on the release of cathepsins in total leucocytes was studied 90 minutes after irradiation. A significant increase of catheptic activity was demonstrated with doses of 600 and 1200 R. The effects on the total leucocytes in vitro were compared with those on the individual leucocyte (lymphocytes and polymorphonuclears). (auth)

**20322** ACCUMULATION OF FRUCTOSE-1,6-DIPHOSPHATE IN X-IRRADIATED RAT THYMOCYTES. Yamada, Takeshi; Ohyama, Harumi (National Inst. of Radiological Sciences, Chiba, Japan). Int. J. Radiat. Biol., 14: 169-74(1968).

Accumulation of fructose-1,6-diphosphate in x-irradiated rat thymocytes was shown to be dependent on x-ray doses ranging from 300 R to 32 kR. Inhibition of cell respiration was also dose-dependent, and oxygen consumption was decreased with increasing doses. There was a marked stimulation of aerobic glycolysis in the dose range up to 8 kR. It was suggested that the accumulation of fructose-1,6-diphosphate was a very early effect of ionizing radiation on the cell and was involved in the decline of ATP. (auth)

**20323** CHROMOSOMAL CHANGES IN THE CHINESE HAMSTER THYROID FOLLOWING X-IRRADIATION IN VIVO. Moore, Wellington Jr.; Colvin, M. (National Center for Radiobiological Health, Rockville, Md.). Int. J. Radiat. Biol., 14: 161-7(1968).

The effects of x rays (10 to 500 R) on the chromosomal-aberration rate of thyroid cells from the Chinese hamster were investigated. The thyroid glands of the animals were irradiated and the thyroids removed either immediately or 30 days later. The glands were trypsinized and the cells grown in tissue culture. It was found that the thyroid cells were sensitive to irradiation as indicated by chromosomal damage at dose-levels as low as 10 R. At 30 days, the average incidence of aberrant cells for all dose-levels had decreased 45 per cent. This decrease could be due in part to growth of the gland. The incidence of aberrant thyroid cells for the 10 R and 500 R exposure was 3.06 per cent and 40.3 per cent for the group sacrificed immediately after irradiation. At 30 days the incidence for these levels was 1.40 per cent and 21.9 per cent respectively. For dose-levels in this study, a linear relationship was observed between the percentage of aberrant cells and the dose. (auth)

**20324** NONTHERMAL EFFECT OF MICROWAVE RADIATION IN VITRO ON PERITONEAL MAST CELLS OF THE RAT. Sawicki, Wojciech; Ostrowski, Kazimierz (School of Medicine, Warsaw). Amer. J. Phys. Med., 47: 225-34(Oct. 1968).

An autoradiographic study was made of uptake of labeled sulfate by peritoneal mast cells irradiated in vitro with microwaves. The dry mass of such cells and the intensity of their metachromasia were also determined. Peritoneal cell suspensions were irradiated in vitro with microwaves of density power 3 mw/cm$^2$. The irradiated mast cells remained alive, but their ability for metachromatic staining was markedly reduced. The dry mass of mast cells, as well as their diameter, diminished by 50 to 65%. Irradiation with microwaves also caused a 2- to 3- fold reduction of $^{35}$S-sulfate uptake by the mast cells. The differences in distribution pattern of grain counts between irradiated and control cells were striking. While the distribution patterns of control cells were normal, those of irradiated cells were of the Poisson type. This was interpreted as a diverse reaction of individual mast cells to microwave stimulus. In the peritoneal cavity of the rat two kinds of mast cells may be distinguished: smaller ones which are more active metabolically and larger ones which are less active and probably the resting forms of mast cells. The latter are also more sensitive to external stimuli. Microwave radiation, therefore, may affect chiefly the population of larger mast cells. Consequently, the number of mast cells with slight or no radioactivity increased, and the distribution patterns of grain counts became strongly right-skewed, i.e., follow Poisson's distribution pattern. Inspection of other cells of the peritoneal cavity, i.e., lymphoid and eosinophilic cells, showed that the intensity of the microwave energy used did not injure them. (BBB)

**20325** THE EFFECT OF GAMMA RADIATION ON CELL ENLARGEMENT AND SIZE DISTRIBUTION OF STRAIN L. Rene, A. A. (Armed Forces Radiobiology Research Inst., Bethesda, Md.); Nardone, R. M. Curr. Mod. Biol., 2: 207-14(Sept.-Oct. 1968).

Enlargement and size distribution of $\gamma$-irradiated (500 to 1500 R) Strain L cells in monolayer culture were studied. The average cell volume, total culture volume, total cell number, and cell size distribution were correlated with the degree of radiation injury and recovery during a 4-day postirradiation period. Cultures irradiated with 500 R showed an inhibition in cell division and giantism followed by recovery, a moderate depression in culture volume, and shifts in cell size distribution toward normal values during the four-day postirradiation period. Cultures irradiated with 1000 and 1500 R also showed dose-correlated inhibition of cell multiplication and giantism. However, these doses had virtually equivalent effects on total culture volume and cell size distribution. The increase in cell size was directly proportional to the three doses used. Cultures irradiated with 1000 R showed, four days later, size changes which reflect a recovery process the cells undergo after the initial enlargement. These data support the view that the factors associated with cell division are much more sensitive than those associated with cell growth. (BBB)

**20326** REPAIR OF SUBLETHAL RADIATION INJURY IN HYPOXIC CELLS OF A $C_3H$ MOUSE MAMMARY CARCINOMA. Suit, Herman; Urano, Muneyasu (Univ. of Texas, Houston). Radiat. Res., 37: 423-34(Feb. 1969).

The cells of a C3H mouse mammary carcinoma were examined for their ability to repair sublethal radiation injury using the split-dose technique and $TCD_{50}$ as the end point ($TCD_{50}$ = radiation dose that yields local control of half of the irradiated tumors). Radiation was administered either under conditions of local tissue hypoxia (application of a clamp across the root of the thigh bearing the tumor for two minutes prior to and during irradiation) or under $O_2$30 psi conditions (respiring pure oxygen at 3 atmospheres of pressure absolute for 15 minutes prior to and during irradiation). The $TCD_{50}$ values were 5372 rads for v = 1 (single dose) and 6853 rads for v = 2 ($D_1$ = 3000 rads, hypoxia; $t_1$ = 6 hours; $D_2$ = variable, hypoxia). Thus, these acutely hypoxic mammary carcinoma cells repaired radiation damage rapidly and extensively; results were consistent with an extrapolation number of approximately 50. To test for repair of radiation damage by chronically hypoxic cells, a first dose of 3000 rads was administered under $O_2$30 psi conditions. Only chronically hypoxic cells would survive such a treatment. After six hr a variable and second dose was administered under hypoxic conditions; $TCD_{50}$ (v = 2) was 5330 rads. This compared with a $TCD_{50}$ of 4860 rads for single-dose irradiation under $O_2$30 psi conditions and suggested that the chronically hypoxic cells were less able to repair radiation damage than acutely hypoxic cells. (auth)

**20327** DOSE CONCEPTS, PRIMARY ACTION, AND THE TARGET THEORY. Fuchs, Georg (Zentral-Roentgen-Institut, Kaiser-Franz-Joseph-Spital, Vienna). Radiol. Aust., 17: 93-6 (1967). (In German).

Basic concepts of dose measurement are discussed. The characteristics of the target theory of radiation energy effect, with chance events taking place according to a Poisson distribution, a sensitive volume, single target events, etc., where the number of target elements is directly proportional to the dose, are discussed. The theory of the indirect radiation effect, where the primary effect of ionizing radiation is taken to be the formation of free radicals and other diffusible agents from water molecules of the cells and tissues is described. The hypothesis that there are both direct and indirect elementary processes involved in each radiobiological event is presented as an intermediate concept. The applications of the theories to the processes of mutation, the genetic code, statistical interpretations of dose, and relations between dose and effect are indicated briefly. (BBB)

## *Invertebrates*

*Refer also to abstract 20167.*

**20328** (ORNL-TM-2466, pp 40-6) EFFECTS OF BETA AND GAMMA RADIATION ON SINELLA CURVISETA (COLLEMBOLA). Styron, C. E. (Oak Ridge National Lab., Tenn.).

Groups of 10 to 12 Sinella curviseta were irradiated in polystyrene boxes. For beta irradiation the boxes were inverted on a $^{90}$Sr-$^{90}$Y source. Adults were exposed to varying doses of beta and $^{60}$Co gamma radiation. Eggs and two-week old juveniles were also given varying doses of beta and gamma radiation. A table is presented to show $LD_{50}$ and RBE values for beta and gamma irradiation of adults, juveniles, and eggs. Fecundity rates of adults were generally reduced by beta and gamma radiation, but at the lowest dose of beta radiation fecundity increased by 49% during the first month. It was concluded that the eggs are the critical stage in the response of the population to ionizing radiation. Their sensitivity is evident whether the parents or the eggs themselves are irradiated. (H.L.W.)

**20329** (ORNL-TM-2466, pp 47-52) HONEY BEE IRRADIATION STUDIES. Shinn, A. F. (Oak Ridge National Lab., Tenn.).

Effects of $\beta$, $\gamma$, and fast neutron radiation on the longevity of laboratory bees and on the daily pollen collection by irradiated colonies of bees in the field were studied. Bees given 5000 rads

of $\beta$, $\gamma$, or fast neutron radiation and kept at 21° C showed no significant reduction in life span, although the life span of irradiated bees kept at 34°C was reduced by 22%. Pollen collection was significantly reduced by radiation. (H.L.W.)

**20330** MITOSIS IN THE CLEAVAGE AND GERM DISC STAGES OF TERMITE EGGS AFTER TOTAL X RADIATION WITH A DOSE OF 5000 R. Truckenbrodt, Wilfried (Heiligenberg-Institut, Ger.). Strahlentherapie, 136: 632-8(Nov. 1968). (In German).

Eggs of termites (Kalotermes flavicollis FABR) were irradiated with roentgen rays up to a dose of 5000 R. The occurrence of mitosis was compared between one and 300 hours after irradiation, in the cleavage stages and in the germ disc. The number of mitoses decreased shortly after irradiation. The cleavage and germ disc stages each behaved in a characteristic way as far as the onset and the duration of the mitosis-free interval was concerned. After a mitosis-free interval, the germ disc stages showed the same lesions, as could be observed a short time after irradiation. The sensitivity of the interphase nuclei changed during the early development of the egg. The mitotic lesion increased with time. In most of the irradiated cleavage stages, the nuclei differentiated and grouped together to form the germ disc, but later on they degenerated. The number of mitoses in the developing eggs, the total number of mitoses and the number of unaffected mitoses decreased with time. The results were discussed. (auth)

**20331** STUDIES ON THE CELLULAR BASIS OF RADIATION LETHALITY. II. SURVIVAL-CURVE PARAMETERS FOR STANDARDIZED PLANARIAN POPULATIONS. Lange, C. S. (Christie Hospital and Holt Radium Inst., Manchester, Eng.). Int. J. Radiat. Biol., 14: 119-32(1968).

The effects of pre- and post-irradiation decapitation, age (sexual maturity), and hypoxic irradiation conditions on planarians were examined to determine those conditions for which radiation lethality was most likely to be determined solely by the degree of depopulation of reproductively intact stem cells. Under such conditions, whole-animal survival parameters were determined for each of the five species and polyploid biotypes studied. Radiation lethality was not affected by decapitation or by age, but oxygen enhancement ratios of 2.5 to 3.4 were obtained. At the level of the whole animal, polyploidy gave no protection against radiation. Species differences were at least as great as generic differences in radiosensitivity. (auth)

**20332** COMPARISON OF RADIATION PROFILES OF ACHETA DOMESTICUS AND TENEBRIO MOLITOR. Menhinick, Edward F.; Crossley, D. A. Jr. (Oak Ridge National Lab., Tenn.). Ann. Entomol. Soc. Amer., 61: 1359-65(Nov. 1968).

Radioinduced mortality was investigated for developmental stages of house crickets, Acheta domesticus (L.), and yellow mealworms, Tenebrio molitor L. Insects were exposed to gamma rays from a $^{60}$Co source at rates of 3 or 30 kiloroentgens (kR) per minute and given total exposures of 1 to 512 kR in 100% increments. Postirradiation temperature was 28°C. Effects were expressed as differences in mean and median life expectancy. In general there was a decline in radiosensitivity with age, although there were exceptions. Acheta was unusually radiosensitive, with life expectancy of all stages severely shortened by exposure to 4 kR. Tenebrio pupae and adults exhibited a survival plateau, with similar life expectancies following exposures from 8 to 32 or 64 kR. Some increase in life expectancy appeared following low exposure doses of radiation. (auth)

**20333** EFFECT OF X-IRRADIATION ON POSTEMBRYONIC DEVELOPMENT OF SARCOPHAGA SEREGRINA ROBINEAU-DESVOIDY. 2. CHANGE OF RADIOSENSITIVITY DURING PREPUPAL AND EARLY PUPAL STAGES. Sasaki, T. (Tohoku Univ., Japan). Dobutsugaku Zasshi, 77: 109-16(Apr. 1968). (In Japanese).

Radiosensitivity, based on criterion of emergence rate, falls down gradually from the time of puparium formation to 22 hr of age. During these stages, a periodical change in sensitivity is observed. After 22 hr of age the radiosensitivity rises with the progress of development and reaches to the maximum at 42–48 hr of age. Thereafter it drops off rapidly. The $LD_{50}$ at $1 \pm 1$, $22 \pm 1$, and $46 \pm 1$ hr of age is 750, 900 and 625 R respectively. The formation of several tissues such as eyes, bristles and muscles is depressed more severely when irradiated in younger stages. We have no evidence that the endocrine system is the target organ for the suppression of tissue formation. For example, the head irradiation does not disturb the histogenesis in thorax and abdomen, and an injection of inokosterone cannot raise the emergence rate of the irradiated pupae. There is a possibility that the amount of damage observed in the nervous system corresponds to the radiosensitivity. (NSA of Japan)

**20334** RADIOSENSITIVITY OF DROSOPHILA EMBRYOS IN RELATION TO AGE, IN AIR, AND IN NITROGEN. Havin, Edel; Oftedal, Per (Norwegian Radium Hospital, Oslo). Int. J. Radiat. Biol., 14: 149-60(1968).

The sensitivity of Drosophila embryos to x rays was investigated for ages between one hour and $3\frac{1}{2}$ hours. The highest sensitivity was found in embryos about $1\frac{1}{2}$ hours old ($LD_{50}$ about 180 R), the lowest in embryos $2\frac{3}{4}$ hours old ($LD_{50}$ about 1700 R). The oxygen enhancement ratio was found to be the same for these two ages, about 2. (auth)

**20335** EFFECT OF TEMPERATURE AND X-IRRADIATION ON PUPAE OF THE FLOUR BEETLE, TRIBOLIUM CONFUSUM. Buckhold, Brenda; Slater, John V. (Univ. of California, Berkeley). Radiat. Res., 37: 567-76(Mar. 1969).

Two effects of pupal irradiation were studied in detail in the flour beetle, Tribolium confusum. Developmental wing abnormalities were found to be temperature-sensitive, reaching a minimum at 28°C. Also, in terms of wing abnormalities, x-ray sensitivity according to age is variable, having two maxima at 10 and 25 hours postpupation and decreasing to control levels at 39 hours postpupation. The length of the pupal stage is protracted with x irradiation or with decreased temperature; the eclosion delay due to the irradiation per se is independent of the temperature following irradiation. An activation energy of 25,300 cal/mole was obtained for the pupal period. (auth)

**20336** DEVELOPMENT OF THE DOUBLE-ABDOMEN MALFORMATION IN EGGS OF SMITTIA PARTHENOGENETICA (DIPT., CHIRONOMIDAE) PARTIALLY IRRADIATED BY UV. Kalthoff, Klaus; Sander, Klaus (Univ., Freiburg i. B.). Arch. Entwicklungsmech. Organ., 161: 129-46(Aug. 1968). (In German).

Anomalous development of eggs of the insect was studied after irradiation with a Hg vapor lamp with 85% of its output at a wavelength of 253.7 nm. Irradiation was carried out at the preblastoderm stage ($M_2$) and lasted 2 min 50 sec. Such uv irradiation of the anterior $\frac{1}{3}$ of the egg during nuclear migration phase frequently was followed by the formation of double abdomens. This type of malformation shows a germ band in which head, thorax, and anterior abdominal segments are replaced by a set of 6 to 8 posterior abdominal segments joined in mirror-image symmetry to the corresponding parts of the original abdomen. The course of development leading to this malformation is visibly aberrant from the blastoderm stage to germ band segmentation only. The two abdomens develop in strict synchrony provided their positions are symmetrical to the equatorial plane of the egg. Asymmetric positions are less frequent and delay temporarily the development of one or the other of the abdomens due to the lack of space. The results are compared to similar malformations in other insect eggs and possible interpretations are reviewed. (BBB)

**20337** BIOSATELLITE II: PRELIMINARY SCIENTIFIC OBSERVATIONS. Reynolds, Orr E.; Saunders, Joseph F. (Office of Space Science and Applications, Washington, D. C.). Curr. Mod. Biol., 2: 147-57(July-Aug. 1968).

Biosatellite II, launched on 7 September 1967 and recovered on 9 September, had as its objectives the study of the effects on living systems of space environment factors, including the interaction of biologic systems with weightlessness, and the combination of weightlessness and onboard $\gamma$ irradiation provided by an $^{85}$Sr source. The seven radiation-weightlessness experiments were carried out with Tradescantia, Habrobracon junglandis, Neurospora crassa, Tribolium confusum, larvae and adults of Drosophila melanogaster, and lysogenic bacteria (Escherichia coli and Salmonella typhimurium). T. confusum (flour beetle) pupae (preirradiated with 1350 R of 180-keV x rays) were orbited in the Biosatellite, half in the presence of $^{85}$Sr and half shielded from it. Identical earth controls were maintained. Of the earth irradiated controls and the shielded flight pupae, 29.9% developed wing abnormalities, whereas the abnormality occurred in 44.8% of the adults from flight irradiated pupae which received an additional 100 to 150 R in orbit. Dominant lethality occurred in $78 \pm 6$% of the offspring of flight irradiated female oocytes, compared to $27 \pm 5$% in the earth-irradiated controls. Females of H. junglandis (parasitic wasp) were orbited in Biosatellite II, and exposed to 0, 500, 1000, 2000, and 4000 R. Enhancement by weightlessness of radiation damage occurred in oocytes in the first meiotic metaphase, where total dominant and recessive lethal mutation frequencies were scored. No significant differences were observed in sperm influences on hatchability or dominant lethality, although males were disoriented in mating function for 2 days postflight. Female behavior was not affected. Females irradiated in flight lived significantly longer than their earth-irradiated counterparts. In Tradescantia (spiderwort), no significant differences in any group, including earth-irradiated and

nonirradiated controls, were found in petal mutations (blue to pink) or dwarf cells. Weightlessness was antagonistic to radiation-induced mutations of blue to pink coloration in stamen hairs. Radiation damage was enhanced by weightlessness for stamen hair stunting, pollen abortion, death, bud abortion, and chromosome aberrations (spindle disturbance). In D. melanogaster adults a slight increase in recessive lethals in the X chromosome of mature sperm was observed. Enhancement of radiation-induced damage by weightlessness was significant for losses of some markers. Antagonism of radiation effects by weightlessness was significant in losses of $Y^+$ and B markers from the Y chromosome and Y and 2nd chromosome translocations. (BBB)

**20338** SEX-RATIO DEPRESSION AS A BROOD-PATTERN CRITERION OF RADIATION DAMAGE IN DROSOPHILA MELANOGASTER. Hannah-Alava, Aloha (Univ. of Turku, Finland). Genetica, 39: 519-43(1968).

The results of analyses of the brood variance in the relative frequency of females to males in the progeny of D. melanogaster males having structurally normal chromosomes, not only established that there is a brood-curve of sex-ratio depression in the progeny of irradiated males, but also revealed that there was a curve of sex-ratio change in successive broods of offspring from unirradiated males even though the ratio of females to males in the total progeny was 1:1. The brood curve of sex-ratio change in both series of control males tended to be bimodal, with an increasing frequency of female offspring during the first five or six days, followed by a progressive decrease until about the 12th day, then subsequently an increase until about the 15 to 16th days, with perhaps again a decrease in the latest (17 to 24d) broods. The bimodality of the curve appeared to be the consequence of a complex relationship between brood-size, brood-rank and sex-ratio change. Following irradiation of the males with 3000 R of x rays, the incidence of female offspring decreased linearly for the first eight days, with a low of 44.32% in the six to eight day broods. This was followed by an abrupt return to a 1:1 sex ratio in the ninth day and subsequent (10 to 24d) broods. The recovery of 50% female offspring in the ninth-day brood was interpreted as supporting evidence for the thesis that this brood was derived from cells that had been spermatogonia at the time of the parental males. (auth)

## Vertebrates

*Refer also to abstracts 20094, 20095, 20104, 20109, 20110, 20124, 20129, 20134, 20136, 20169, 20261, 20266, 20412, and 20433.*

**20339** (AD-673351) EFFECT OF HEAD VERSUS TRUNK X-IRRADIATION ON AVOIDANCE BEHAVIOR IN THE RHESUS MONKEY. Technical Report for January-November 1967. Chapman, Paul H.; Hurst, C. M. (School of Aerospace Medicine, Brooks AFB, Tex.). Apr. 1968. 18p. (SAM-TR-68-37). CFSTI.

The effect of large doses of ionizing radiation delivered to the head or trunk alone on learned avoidance behavior in primates (Macaca mulatta) was investigated. Two groups of eight animals each were exposed to either head or trunk x irradiation from a high energy source. A total dose of 18,070 Rads was given at a dose rate of 280 Rads per minute. Irradiation of either the head or trunk alone was found to produce performance decrement; however, the character of the decrement differed for the two groups. One-half of the trunk-irradiated animals showed an early reversible decrement after doses of 1,000 to 5,000 Rads while the head-irradiated group generally performed well until 10,000 to 16,900 Rads had been delivered, at which time a precipitous, irreversible incapacitation occurred which was accompanied by extensive signs of CNS damage. The results suggest the importance of indirect as well as direct effects of irradiation on the central nervous system and its function particularly in relation to the period of early, reversible incapacitation after large doses of radiation. (auth)

**20340** (AD-673352) EARLY HEMATOLOGIC CHANGES IN THE RHESUS MONKEY AFTER SUPERLETHAL MIXED NEUTRON-GAMMA IRRADIATION. Technical Report for December 1966-December 1967. Anderson, Donald R.; Young, Robert J. (School of Aerospace Medicine, Brooks AFB, Tex.). May 1968. 14p. (SAM-TR-68-45). CFSTI.

To determine early hematologic response to mixed neutron-$\gamma$ irradiation, 20 Macaca mulatta monkeys were exposed to pulsed doses of 2,500, 3,750, and 5,000 Rads. Hematologic data at four hours postirradiation indicated a marked leukocytosis in all groups. The cellular increase was due to the increase of neutrophils contrasted to the lymphocytes, which decreased to less than half their baseline value. There was also a thrombocytosis at four hours postirradiation. Serum enzyme concentrations were determined with observed increases of lactic dehydrogenase and glutamic oxalacetic transaminase; however, the response was highly variable. (auth)

**20341** (BNL-50058, pp 169-78) STOCHASTIC MODELS OF CELL PROLIFERATION AND CELL RESPONSE TO RADIATION. Paskin, A.; Bronk, B. V.; Dienes, G. J. (Brookhaven National Lab., Upton, N. Y.).

A stochastic technique of following cell proliferation is presented. By means of this technique cell proliferation is quantitatively described in terms of experimentally observable parameters. The stochastic model reproduced the well-known cyclic characteristics of the cell proliferation process. Further, the technique permitted quantitative and simultaneous treatment of the cell proliferation process together with perturbing and recovery processes. Calculations were sufficiently specific to be verified by comparison with experiment. The combination of this model of the kinetics of cell proliferation with the kinetics of radiation response and recovery and is described. (C.O.)

**20342** (BNL-50058, pp 212-22) HOMEOSTASIS IN IRRADIATED TISSUES. Lamerton, L. F. (Institute of Cancer Research, Sutton (England). Surrey Branch).

The comparative response of the erythropoietic system of the rat to bleeding and to continuous and acute irradiation was studied. Changes of flow rate into the recognizable precursor compartment, multiplication factor in this compartment, and measurement of cell proliferation rate and transit time within the different compartments were studied. Bleeding and irradiation were found to evoke different patterns of homeostatic mechanisms. The relevance of these findings to the general problem of homeostasis in irradiated tissues is briefly discussed. (C.O.)

**20343** (BNL-50058, pp 263-83) CELLULAR AND HUMORAL FACTORS IN RECOVERY FROM RADIATION INJURY. Cole, Leonard J. (Naval Radiological Defense Lab., San Francisco, Calif.).

The processes involved in recovery from radiation injury in mammalian organisms were discussed. Some experimental evidence for possible interactions, for example, between spleen shielding and recovery of the proliferative ability of the irradiated kidney after unilateral nephrectomy, and between limb shielding and intestinal radiation deaths was considered. Although it was established that proliferation and differentiation of the hemopoietic stem cell compartment is one of the prime mechanisms of recovery from radiation injury, little emphasis was placed on the consequences and implications of the clonal repopulation of the reticular tissues seen after high sublethal radiation doses. On this basis it was possible, for example, that some biological characteristics of these repopulated clones differed considerably from any one irradiated individual to another, so that individual biochemical or functional aberrations arose. The results of studies on recovery from radiation injury to the mammalian immune system indicated the complexities involved in a situation in which two or more cell types were involved in the final elaboration of humoral antibody or in the homograft response. The interactions among these cell types probably accounted for the anomalous pattern of recovery observed. No definitive therapeutic or enhanced recovery effects of post-treatments with chemical substances or subcellular fractions were established. Studies along these lines were replete with pitfalls. However, several recent experimental approaches to this problem, as well as advances in molecular radiobiology theory, suggested that further pursuit of this goal should be worthwhile. (C.O.)

**20344** (CONF-680507-, pp 143-53) EVALUATION OF LARGE ANIMAL STUDIES ON RECOVERY FROM RADIATION INJURY. Rust, John H. (Chicago Univ., Ill.).

Studies on cattle exposed to fallout from the first atomic weapon detonated at Alamagordo, New Mexico, and other studies on radiation injuries in animals are reviewed. Tables are presented to show lethal doses for dogs, sheep, and swine; effects of three successive whole-body gamma exposures on dogs; response of the burro to protracted whole-body gamma exposure; and hematocrit values in dogs exposed to repeated doses of 150 rads of x rays. Results of various studies are contradictory and cannot be extrapolated to man. (H.L.W.)

**20345** ACUTE RESPONSE OF GERM-FREE AND CONVENTIONAL MICE TO IONIZING RADIATION. Anderson, Robert E.; Howarth, John L.; Stone, Robert S. (Univ. of New Mexico, Albuquerque). Arch. Pathol., 86: 676-80(Dec. 1968).

The response of female mice to a single whole-body exposure of ionizing radiation was examined. The animals were divided into 3 groups: (1) germ-free mice housed in plastic isolators and fed sterile food and water; (2) conventional mice housed and fed as described above; and (3) conventional mice housed in a standard

vivarium and fed conventional food water. The results demonstrated that the immediate response following such exposure is greatly modified in the germ-free state with differential survival times favoring germ-free over conventional mice. Autopsy results confirmed that this difference is primarily due to bacterial infection in the conventional group, while survival data suggested that such infection is of both endogenous and exogenous origin. The slope of the survival curve suggested that the acute response to ionizing radiation of conventional mice housed in plastic isolators may be more complex than the response of conventional mice housed in the vivarium of germ-free mice. Death in the latter group appeared to be related to the consequences of hematopoietic damage and more specifically to severe anemia; the lethal dose range in this group was surprisingly narrow. Death in the conventional-vivarium group was also related to hematopoietic failure, but leukopenia may be of greatest importance since most cases were complicated by infection. Contrary to what might be expected, exogenous organisms played an important role in such infection and may be more important than endogenous organisms at the higher dosage levels. (BBB)

**20346** THE ACTION OF X IRRADIATION ON THE REGENERATION FIELD OF THE FORELIMB OF THE ADULT NEWT, DIEMICTYLUS VIRIDESCENS. Oberpriller, Jean Colville (Tulane Univ., New Orleans). J. Exp. Zool., 168: 403-22 (Aug. 1968).

Effects of x irradiation on regeneration of the urodele forelimb were studied. Right and left forelimbs of adult newts were parabiosed along their posterior edges, after the right limbs had been irradiated with 2000 R. Forelimbs of control animals underwent similar operations. However, both limbs remained unirradiated. The angles which the stumps made with each other were classified as parallel, acute, and wide angles. Sixty days after amputation of these limbs, the cartilage patterns of the two groups were compared. In the control series, as the angle between the stumps was increased, the number of digits in the bilaterally symmetrical regenerates decreased, with a loss of central structures. At very wide angles, the doubled stumps produced no regenerates. In the experimental series, there were no interference effects from the irradiated right forelimbs. Single normal asymmetric left hands regenerated, despite widening angles between stumps. Sham operations, which were performed on irradiated and unirradiated limbs, had no effect on the regenerative capacities of the limbs, with no regeneration in 97.7% of the irradiated limbs and normal regeneration in 91.1% of the unirradiated limbs. X rays seemed to act on the limb to eliminate the interference effects normally found in regenerating doubled stumps, presumably involving a disruption of the longitudinal control of the regeneration field. The loss of inter-tissue communication and possible loss of the bioelectric field is discussed. (BBB)

**20347** CEREBRAL CHANGES IN RATS IN POSTIRRADIATION DISEASE. Ojak, Maria (Inst. of Experimental Pathology, Warsaw). Patol. Pol., 17: 321-7 (July-Sept, 1966). (In Polish).

Studies were conducted on 30 rats (wt 175 to 375 g, 3 to 12 months old) that received 600 R of whole-body x-irradiation at 50.8 R/min. Decapitation followed 6 weeks later, and the brain, removed for histopathologic examination, was separated into 5 parts, which included medulla oblongata, pons, ganglia, midbrain, and cortex, all specifically prepared by selective staining. Scattered over all parts of the brain examined were prominent vascular changes with thickening of the vessels, evidently originating from meso- and ectodermal cells. The endothelium of capillary vessels showed swellings and sporadic necroses. The greatest number of changes were noted in adventitial cells of the central nervous system in a form of pyknosis of numerous nuclei, also necroses in various stages in single cells and in whole groups of cells. Vacuoles were found in cytoplasm of vascular cell plexuses. Individual nerve cells revealed single neurons in an ischemic stage, while the signs of injury in some cells were of even greater severity. Some nuclei were found to have double nucleoli. The white matter revealed nonstained zones near the vessels, and occasionally edematous axons. Some axial fibers had disintegrated to a point of fragmentation with puffed-out dense areas on their periphery. All changes reflected an increased permeability of vascular walls and penetration of fluid into local areas, thus presenting a picture of cerebral swellings, which with the nuclei of oligodendroglia and areas of demyelinization, resulted in a sponge-like state of the tissue. The described changes appeared in both white and gray matter of the brain, but the gray matter changes were less severe. (BBB)

**20348** EFFECTS OF SMALL DOSES OF GAMMA RADIATION ON THE POSTEMBRYONIC DEVELOPMENT AND PRODUCTIVENESS OF POULTRY. Naidenskii, M. S. Tr. Mosk. Vet. Akad., 49: 218-24 (1966). (In Russian).

Experiments began with 2100 eggs from hens previously irradiated during the embryonic stage (group 1) and with 2100 eggs from nonirradiated hens of the same breed (group 2-control). Prior to hatching in incubators, each group of eggs was divided into 2 subgroups: a) experimental, and b) control. Groups 1-a and 2-a were irradiated on the 1st and the 3rd day of incubation for 5 min, and then up to 8 hr daily from the 6th to 20th day. The total dose of $\gamma$ irradiation was 1.4 R given at 0.0002 R/min. While the chicks were growing, they were weighed each month individually, and their vitality and deficiencies were studied. The productiveness of laying hens was also observed. The physiological conditions of birds were examined with respect to hematological, biochemical, and histological standards and were found to be normal. It was noted that the stimulatory effects of $\gamma$ radiation given during incubation extended far past the hatching period into the full development stage of birds. Grown poultry possessed good vitality, brightly colored beak and legs, and laid normal-size eggs with larger yolks than the control birds. The quality of meat was high. (BBB)

**20349** EXPERIMENTAL PRODUCTION OF ATHEROSCLEROSIS IN MICE. PART 1. EFFECT OF VARIOUS SYNTHETIC DIETS AND RADIATION ON SURVIVAL TIME, FOOD CONSUMPTION, AND BODY WEIGHTS IN MICE. Vesselinovitch, D.; Wissler, R. W.; Doull, J. (Univ. of Chicago). J. Atheroscler. Res., 8: 483-95 (May-June 1968).

The influence of various atherogenic and high-fat diets on the survival time, body weight, and food consumption of $CF_1$ male mice exposed to acute and chronic x irradiation was investigated. The diets Thomas (D) and Fillios (E) that were used caused marked weight loss and severe mortality in the nonirradiated animals. The other three diets Wilgram (F), synthetic (C), and Purina Nursing Chow (B) also produced severe stress in both the control and irradiated mice. These animals failed to exhibit a normal growth rate and had a significant shortened life span in comparison with animals fed the control diet. The median survival time of the animals fed the experimental diets combined with x irradiation at the rate of 20 R/day and a total accumulated dose of 1200 R was less than that of animals fed the control diet. However, there was little difference in the median survival time of irradiated and nonirradiated groups fed each of the individual experimental diets. Increase of the daily radiation dose level to 40 R/day resulted in about 50% shortening of median survival time compared with nonirradiated mice fed the same diet. Feeding of the atherogenic and high-fat diets to mice given single whole-body doses of 400 and 450 R did not markedly shorten the median survival time when compared with that of mice fed the control diet. Synthetic high-fat diet C appeared to cause some prolongation of postirradiation survival time. (BBB)

**20350** EXPERIMENTAL PRODUCTION OF ATHEROSCLEROSIS IN MICE. PART 2. EFFECTS OF ATHEROGENIC AND HIGH-FAT DIETS ON VASCULAR CHANGES IN CHRONICALLY AND ACUTELY IRRADIATED MICE. Vesselinovitch, D.; Wissler, R. W. (Univ. of Chicago). J. Atheroscler. Res., 8: 497-523 (May-June 1968).

Gross and microscopic findings resulting from various atherogenic and high-fat diets, together with chronic and acute x-irradiation doses, were compared in $CF_1$ male mice. The synthetic diets used included a high-fat control diet (C), Thomas (D), Fillios (E), or Wilgram (F) diets which produced severe pathological disturbances in nonirradiated and irradiated animals. Some mice received 20 R/day of whole-body x irradiation 5 times weekly (daily exposure), or a total of 1200 R. Others received 40 R/day for 12 weeks, 5 times weekly, accumulating a dose of 2400 R. Some received single whole-body exposures of 400 and 450 R at the beginning of the experiment. There were six diet subgroups in each of the radiation groups. The weight of the liver and spleen in particular was decreased in mice fed atherogenic or synthetic control diets. Chronic radiation exposure either alone or in combination with diet C, F, or B caused marked decrease in the testis weights. The combination of chronic irradiation exposure and diet F decreased the degree of lipid deposition and resulted in less calcification of the blood vessels. The same combination increased incidence of thrombosis. With only chronic x irradiation, mild hyalinization of collagen fibers in the aorta and calcification of coronary and testicular arteries were observed. Intimal lipid deposition was present in coronary arteries, as well as focal mononuclear infiltration, patchy necrosis, and calcification in the myocardium. Acute irradiation resulted in loss of smooth muscle cells and calcification of aortic media, calcification and hyalinization of the pulmonary arteries, and mononuclear infiltration, necrosis, and calcification of the myocardium. The combination of atherogenic diets with acute irradiation did not decrease sudanophilia or calcification of blood vessels. (BBB)

**20351** INFLUENCE OF X IRRADIATION OF RABBIT SPERMATOZOA ON FERTILIZATION AND EARLY CLEAVAGE. Bedford, J. M. (Columbia Univ., New York); Hunter, R. H. F. J. Reprod. Fert., 17: 49-57(Oct. 1968).

Exposure of rabbit semen to x irradiation did not reduce the fertilization rate until doses of >25,000 R were used, although motility was noticeably affected at 15,000 R. Evidence of a depressant effect of much lower doses of x irradiation on the fertilizing ability of rabbit spermatozoa was obtained, however, by using a more sensitive system in which irradiated aliquots from an ejaculate were inseminated mixed together with an exactly equivalent volume of untreated semen from the same ejaculate. Under these competitive conditions the fertilizing ability of spermatozoa was found not to be affected by a dose of 10,000 R but was significantly depressed by 15,000 R, as judged by an increase in the proportion of normally developing to retarded ova, recovered 50 hr after an ovulation injection of human chorionic gonadotropin. It appears that this depressant effect is exerted at the site of fertilization rather than on sperm transport. X irradiation of spermatozoa did not increase polyspermic or delayed fertilization, nor did irradiation have any significant effect on the formation of the male pronucleus. A dose-response effect was seen at the time of the first cleavage division, for at 24 hr the cleavage rate of control ova (68.5%) was similar to that of ova fertilized by spermatozoa treated with 10,000 R (68%), but only 33% of ova fertilized by spermatozoa treated with 20,000 to 25,000 R had cleavage at this time compared with 78% of their controls. At 29 and 50 hr several ova fertilized by irradiated spermatozoa remained at the pronuclear stage or at metaphase of the first cleavage division, and even at 50 hr most had only reached the 2-cell stage. (BBB)

**20352** STUDIES ON THE EFFECTS OF MICROWAVES OF LOW-DENSITY RADIATION ON THE TESTES OF RABBITS. Lenko, Jan; Waniewski, Edward; Wochna, Zdzislaw (Klinika Urologiczna, Warsaw). Pol. Tyg. Lek., 21: 1475-7(1966). (In Polish).

Two groups of mature male rabbits, five in each group, received for 10 succeeding days, 2 hr per day, whole-body microwave radiation of about 10 $\mu w/cm^2$ at the 10-cm band. One cage that was hermetically sealed with the rabbits inside was placed in the immediate vicinity of a magnetron, where the radiant energy range was the lowest, and the other cage, open to the air, was positioned outside the building, in the open air near the radar antenna. All rabbits of both groups received the same chronic radiation doses. Next day, after completion of irradiation, all the rabbits were killed and their testes were subjected to morphological and histoenzymatic microscopic examinations. In the testes of both groups, identical lesions were found in the germinative epithelium, as well as cellular depopulation and degenerative changes. In addition to venous congestion, subcutaneous layers of testes revealed minute pools of albuminous fluid, homogeneous and clotted. The extent and severity of changes in testes of rabbits appeared exactly alike and, according to the data of previous experiments, they were considered in a moderate stage, which was regarded reversible. Four radiographs of the injured testes are illustrated. After evaluating the results of their studies, the authors ruled out a possibility of ionizing radiation exerting a damaging action on the testes, or combined effects of ionizing and microwave radiation. The cumulative changes in testes of the rabbits appeared to result entirely from the effects of low-density chronic microwave irradiation. (BBB)

**20353** EFFECT OF ACID HYDROLYSIS ON INCORPORATED THYMIDINE IN IRRADIATED BONE-MARROW CELLS. Benes, L.; Rotreklova, E. (Biophysical Inst., Brno). Int. J. Radiat. Biol., 14: 271-5(1968).

Bone marrow cells were taken from guinea pigs after a whole-body exposure of 600 R. They were pulse-labeled with $^3H$-TdR and the effects of hydrolysis with 1N HCl was studied at different time intervals. From autoradiographs it was seen that about 25% of DNA tritium activity was lost from the hydrolysis-treated cells from irradiated animals. (F.M.M.)

**20354** RADIATION-INDUCED EXPERIMENTAL CANCER OF THE ESOPHAGUS. Gates, Olive; Warren, Shields (Harvard Cancer Commission, Mass. New England Deaconess Hospital, Boston). Contract AT(30-1)-3777. Amer. J. Pathol., 53: 667-85(Nov. 1968). (NYO-3777-22).

Carcinoma of the esophagus, virtually unknown as a spontaneous murine tumor, has been induced in eight strains of mice by continuous gamma irradiation. The development of carcinoma was dependent primarily on the intensity of the radiation exposure. Irradiation was a sufficiently powerful carcinogenic stimulus to eliminate possible differences in sex or strain sensitivities, except perhaps for the Ajax and BALB strains. There appeared to be optimal dose rates for the development of cancer of the esophagus, varying slightly with strain. The rarity of cancer induced by very high doses is consistent with an optimal dose rate. However, the possibility of transiently existing lesions cured by further irradiation must be considered. Local interactions of damaged tissues may account for the variation in rates of cancer induction, especially at low exposure levels. (auth)

**20355** STUDIES ON BIOLOGICAL RADIATION PROTECTION. PART 88. QUANTITATIVE RELATIONS IN RADIOACTIVE IRON INCORPORATION IN ERYTHROCYTES AFTER WHOLE-BODY IRRADIATION OF MICE. Moenig, Hans; Maier, Ulrike (Univ., Freiburg i. B.). Strahlentherapie, 136: 596-603(Nov. 1968). (In German).

The incorporation of $^{59}Fe$ was studied in white female mice after total body irradiation, and related to the dose and the time between irradiation and injection of the radioisotope. When the $^{59}Fe$ was injected 24 hours after irradiation, a dependence of the iron incorporation was found between the doses of 20 and 75 R. The threshold dose for damage of the erythropoietic system was about 25 R. The rate of incorporation of iron decreased if the dose increased but not between 75 and 640 R. When the time of injection of $^{59}Fe$ was modified one could follow the evolution of the damage and eventually the recovery of the erythropoietic system. There was a linear relationship between dose and time of recovery in the dose range of 20 to 640 R. The $^{59}Fe$ incorporation test could, however, hardly be used as a biological dosimeter. (auth)

**20356** ELECTRORETINOGRAPHIC RESPONSES OF THE RABBIT AFTER X IRRADIATION. Devi, Sumana K.; Riley, Edgar F.; Burns, Charlotte A. (Univ. of Iowa, Iowa City). Contract AT(11-1)-1024. Invest. Ophthalmol., 7: 219-26(Apr. 1968). (COO-1024-28).

The inhibitory effects of 250 kvp x radiation on the electroretinographic response (ERG) of the rabbit were investigated. Rabbits were exposed (head only) to either a single dose ranging from 3,000 to 8,000 rad or to a fractionated dose, two doses of 3,000 rad each with an interval of 5 days. ERG responses of the dark adapted eyes of the rabbit were determined prior to exposure and at various intervals from 30 minutes to 1 week (2 to 8 weeks in a few cases) after irradiation. At 30 minutes after a dose of 5,700 rad or more, the b-wave was extinct and the a-wave nearly so. Both the a- and b-waves were extinct at 1 hour after 6,000 rad. No recovery was evident from the ERG responses obtained during the first 3 weeks after 6,000 rad. At 30 minutes after a dose in the range from 3,000 to 5,500 rad, the amplitudes of the a- and b-waves were inversely related to dose. In this dose range, various recovery patterns were indicated. After a single dose of 3,000 rad, no significant changes in the ERG response were found at 30 minutes, the amplitudes of the a- and b-waves were about 60 per cent of the control mean at 1 day, and the amplitudes were in the normal range by the third week indicating a complete recovery. When a dose of 6,000 rad was fractionated, the amplitudes of the a- and b-waves were 10 to 15 per cent of the control mean at 30 minutes after the second dose of 3,000 rad. The amplitudes had increased to 32 to 36 per cent at 7 days after irradiation indicating some recovery. (auth)

**20357** SENSITIZING EFFECT OF CHLORTRIANISEN IN COMPARISON WITH NITROGEN MUSTARD. Schunk, Josef (Abteilung Forschung, Entwicklung, Erprobung und Lehre des Bundesamtes fuer Zivilen Bevoelkerungsschutz, Bad Godesberg, Ger.). Strahlentherapie, 136: 639-40(Nov. 1968). (In German).

The effects of Chlortrianisen (Merbentul® Tace®) were compared with nitrogen mustard in mice. This substance has, besides its protective effect against roentgen rays, an important sensitizing influence, that could be demonstrated by giving chlortianisen five minutes to 30 days before the application of trichlor-triethanolamine. (auth)

**20358** EFFECT OF CHOLINE ON THE METABOLISM OF PHOSPHOLIPIDS UNDER RADIATION LESION. Sopin, E. F.; Gaidai, V. M. (Shevchenko State Univ., Kiev). Ukr. Biokhim. Zh., 40: 527-31(1968). (In Ukrainian).

The content and renewal intensity were studied of total and separate phospholipids in muscles, liver and brain of guinea-pigs under normal conditions, at the terminal stage of radiation sickness caused by a single total x ray irradiation dose of 500 R as well as during administration of choline to the normal and irradiated animals. It was established that choline administration for 10 days resulted in an increase of both total and separate phospholipids in all the tissues under investigation in comparison with irradiated animals, which were not subjected to choline administration. The renewal intensity of the phosphate group of

total and separate phospholipids in all tissues under investigation increased sharply while in the irradiated animals which were not subjected to choline administration it considerably decreased. (auth)

**20359** NITROGEN COMPOUND CONTENT AND AMINOTRANSPHERASE ACTIVITIES IN SKIN OF CALVES AT ULTRAVIOLET IRRADIATION. Golovach, V. M.; Bortnovskii, P. F. (Inst. of Physiology and Biochemistry of Domestic Animals, Lvov). Ukr. Biokhim. Zh., 40: 523-6(1968). (In Russian).

It was established that 25-minute ultraviolet irradiation with the lamps "ПРК-2" and "ЄУВ-30" for nine hrs twice a week resulted in a rise of polypeptide nitrogen concentration in skin during irradiation and in its drop after irradiation. In the same period a decrease was also marked in the amino nitrogen content of calves irradiated with the lamps "ЄУВ-30". Marked increase in the urea content in skin was observed during the final period of the experiment in the animals irradiated with lamps "ПРК-2". Activity of aminotransferases, especially of aspartate aminotransferase, sharply increased. Alanine aminotransferase activity increased only in the calves irradiated with the lamps "ПРК-2" in the final period of the experiment. (auth)

**20360** CONTENT OF HEXOKINASE AND SOME COMPONENTS OF THE CITRIC ACID CYCLE IN THE MOUSE LIVER AFTER WHOLE-BODY IRRADIATION. Waldschmidt, Marianne; Koenneker, Edith (Univ., Freiburg i. B.). Strahlentherapie, 136: 581-7(Nov. 1968). (In German).

The level of $\alpha$-oxoglutarate in mouse liver was not influenced by irradiation. The levels of kinase, malate dehydrogenase and isocitrate dehydrogenase in cytoplasm and mitochondria were determined after a whole-body X irradiation with 690 R. The activity of hexokinase in cytoplasm was decreased after 24 hours fasting but comparatively increased six hours and one to two days after irradiation. The activity of malate dehydrogenase in cytoplasm was not altered after fasting or irradiation. The activity of isocitrate dehydrogenase in cytoplasm and mitochondria was significantly decreased 12 hours and three to 14 days after irradiation of fasted mice, but was not affected by 24 hours fasting. The level of malate was significantly decreased after 24 hours fasting but increased from the first day after irradiation of fed and fasted animals. (auth)

**20361** FURTHER INVESTIGATIONS ON THE RELATION BETWEEN IONIZING RADIATION AND STAPHYLOTOXIN EFFECTS. PART III. Chudomel, Vladimir; Rerabek, Emmy; Svoboda, Milan; Solar, Vaclav (Institut fuer Haematologie und Bluttransfusion, Prague. Institut fuer Serum und Impfstoffe, Prague). Strahlentherapie, 136: 478-83(Oct. 1968). (In German).

The effect of ionizing radiation combined with subsequent administration of staphylococcus toxin was investigated in CBA-mice. In tissue culture experiments, the influence of serum of total irradiated guinea pigs and of staphylococcus toxin on proliferation of mouse fibroblast strain L was studied; further, the relation to the applied dose, to the time of bleeding the animals after irradiation and to the mode of action of toxin was investigated in detail. Total body irradiation and subsequent administration of toxin accelerated the death of the animals in a significant manner. In the mouse fibroblast strain L, cultivated in the presence of serum of total irradiated guinea pigs, cellular damage could be found, the degree of which was in relation to the dose applied and depended on the time elapsed between irradiation and the bleeding. If the culture medium was supplemented with amounts of staphylococcus toxin which were ineffective per se, the cellular injuries seemed to be increased in accordance with the dose applied. (auth)

**20362** PROLONGATION OF THE SURVIVAL OF SKIN HOMOTRANSPLANTS BY THE INTRALYMPHATIC INJECTION OF RADIOACTIVE ISOTOPES. Szabo, Gyorgy; Balint, Jozsef; Jankovics, Rezso; Sarmai, Erno; Magyar, Zsuzsa (National Inst. of Traumatology, Budapest). Kiserl. Orvostud., 20: 442-7(Aug. 1968). (In Hungarian).

The survival of skin homotransplants transplanted into the ear of rabbits was considerably prolonged by the injection of a small dose of $^{111}$Ag-colloid or $^{131}$I-Lipiodol into the central lymphatic vessel of the ear. The radioactive substance could still be demonstrated several weeks later in the regional lymph nodes and caused destruction of the lymphoid tissue. (auth)

**20363** COMPARISON OF THE BIOLOGICAL EFFECTIVENESS BETWEEN CONVENTIONAL X-RAYS AND HIGH ENERGY RADIATIONS. Okamura, Shigeaki; Murakami, Koichi (Kyushu Univ., Japan). Fukuoka Igaku Zasshi, 59: 475-92(1968). (In Japanese).

Comparison of the biological effects between high energy photons ($^{60}$Co $\gamma$ rays, 15 MV x rays) and conventional x rays was performed. As test systems, $LD_{50/30}$ of the CF #1 mouse, weight loss and nucleic acids contents loss of the spleen and thymus, leucocyte counts loss and other blood elements loss, weight loss of the testes, and growth rate reduction of the solid form of the Ehrlich acites tumor were adopted. The equal effect ratio and equal dose ratio of normal test systems were 0.7 to 0.9, and those of acites tumor were 0.9 to 1.0. This difference of the values between normal test systems and pathologic system is advantageous for the high energy radiation therapy. (NSA of Japan)

**20364** MODIFICATION OF ONTOGENETIC PATTERNS IN MAMMALIAN BRAIN. Purpura, Dominick P.; Shofer, Robert J. (Columbia Univ., New York). Progr. Brain Res., 22: 458-79(1968).

Normal morphological and physiological developmental patterns in feline cerebral and cerebellar cortex are summarized in order to provide a basis for analysis of the pathophysiological effects of two types of injuries to the immature brain. Surgical interruption of axons of pyramidal neurons markedly accelerates development of intracortical axon-collaterals which establish synaptic relations with adjacent arciform pyramidal neurons. One consequence of this re-organization of synaptic pathways is reflected in the development of powerful excitatory synaptic activities in traumatized regions of immature neocortex. Effects of x irradiation of cerebellar cortex in newborn kittens are defined primarily in terms of loss of the external granular layer and modification of Purkinje cell morphogenesis. Major alterations in electrophysiological properties of irradiated cerebellar cortex are seen in evoked responses to folial surface and motor cortex stimulation. These alterations are considered expressions of radiation-induced maturation acceleration and re-organization of synaptic pathways and possible changes in membrane properties of Purkinje cell dendrites. The data obtained in these ontogenetic studies of pathophysiological processes indicate that different types of insults to the immature brain may produce similar overt effects, i.e., changes in excitability by entirely different mechanisms. (auth)

**20365** EFFECT OF REPEATED POSTIRRADIATION BLEEDING ON THE ERYTHROPOIETIC REGENERATION OF IRRADIATED RATS. Ninkov, Vukosava; Dragic, Marko (Boris Kidric Inst. of Nuclear Sciences, Belgrade). Strahlentherapie, 136: 472-7(Oct. 1968).

The effect of postirradiation multiple bleeding on the course of a regeneration process in erythropoiesis of rats irradiated with 600 R was studied. The results obtained showed that three-fold postirradiation bleeding has a positive effect on the onset and intensity of the regeneration processes of erythropoiesis as compared with irradiated animals only. This effect was the same as obtained after setting single postirradiation bleeding, at the same degree of induced anemia. (auth)

**20366** RECOVERY AND REPOPULATION IN MOUSE SKIN AS A FUNCTION OF TIME AFTER X-IRRADIATION. Denekamp, J.; Ball, M. M.; Fowler, J. F. (Royal Postgraduate Medical School, London). Radiat. Res., 37: 361-70(Feb. 1969).

Gross skin reactions of mouse feet have been studied after one or two doses of x-rays. For split-dose irradiations a first dose of 1000 rads was used. The total dose for various fractionation intervals to produce a chosen level of skin reaction (integrated over 8 to 30 days) was determined. The dose increment ($D_2 - D_1$) necessary to produce the same effect with a split dose ($D_2$) as with a single dose ($D_1$) was determined for the various intervals. The value of $D_2 - D_1$ is interpreted as being caused by prompt intracellular recovery from sublethal injury; progression through phases of different sensitivity in the cell cycle of cells which had been partially synchronized by the first dose; and an increase in basal cell number by repopulation. The dose increment in the first 24 hours was found to be 500 to 550 rads, and a further increment of 580 rads was required from 1 to 21 days. These values are in close agreement with the results of clone-counting experiments using the Withers technique on the same mice (Emery et al., 1969), and with repopulation rates reported previously in pigs and in human skin. (auth)

**20367** SOME BIOLOGICAL EFFECTS OF LOW-ENERGY PROTONS ON SKIN. Siegal, Alan M.; Casey, Harold W.; Traynor, Joseph E. (School of Aerospace Medicine, Brooks Air Force Base, Tex.). Radiat. Res., 37: 323-33(Feb. 1969).

Rhesus monkeys (Macaca mulatta) were exposed to 28-MeV, 21-MeV, 14-MeV, and 5-MeV protons at the Oak Ridge Isochronous Cyclotron with doses from 500 to 2000 rads. The theoretical depths of penetration of these low-energy protons are 8, 5, 2, and 0.4 mm, respectively. Acute skin damage was assessed. No clinically observable effects resulted from exposure to 5-MeV protons up to 2000 rads. Acute skin effects were noted following exposures to 14-MeV, 21-MeV, and 28-MeV proton irradiation, and these effects were found to be a graded response dependent on both proton energy and dose. (auth)

**20368** EFFECT OF SYNGENEIC BONE MARROW CELL DOSE ON THE 30-DAY AND 90-DAY $LD_{50}$ OF X-IRRADIATED MICE. Doherty, David G. (Oak Ridge National Lab., Tenn.). Radiat. Res., 37: 299-304(Feb. 1969).

The radiation $LD_{50}$ response at 30 days and at 90 days was determined for (C57BL/Cum ♀ × C3H/Anf Cum ♂) $F_1$ mice received syngeneic marrow doses from $5 \times 10^4$ to $2 \times 10^8$ nucleated cells. A biphasic response proportional to the logarithm of the cell dose was obtained, with the break coming at about $2 \times 10^5$ cells. The results suggest an optimum cell dose of 2 to $5 \times 10^6$ nucleated cells to obtain recovery from supralethal radiation doses. (auth)

**20369** EFFECT OF HIGH-PRESSURE OXYGEN ON ACUTE RADIATION MORTALITY IN MICE. Christensen, Gerald M.; Dahlke, L. W.; Griffin, J. T.; Moutvic, J. C.; Jackson, Kenneth L. (Univ. of Washington, Seattle). Radiat. Res., 37: 283-6(Feb. 1969).

Groups of mice were x-irradiated in either air at 1 atmosphere or pure oxygen at 3 atmospheres to assess to effect of exposure in high-pressure oxygen on acute radiation injury. Exposure in air resulted in an $LD_{50(30)}$ value of 617 R, while exposure in 3 atmospheres of oxygen resulted in an $LD_{50(30)}$ of 540 R. These data indicate sensitization of 13% owing to the presence of high-pressure oxygen. The $LD_{50(5)}$ values were 1025 R for exposure in air and 900 R following irradiation in high-pressure oxygen, resulting in a sensitizing effect of 12% for acute gastrointestinal radiation injury. (auth)

**20370** THE EFFECTS OF EXTRACORPOREAL IRRADIATION OF CIRCULATING BLOOD AND THORACIC DUCT LYMPH ON TETANUS ANTITOXIN RESPONSES IN CALVES. Stoner, R. D.; Cottier, H.; Sipe, C. R.; Chanana, A. D.; Joel, D. D.; Cronkite, E. P. (Brookhaven National Lab., Upton, N. Y.). Radiat. Res., 37: 539-50(Mar. 1969).

Calves were given daily extracorporeal irradiation of circulating blood (ECIB), continuous extracorporeal irradiation of thoracic duct lymph (ECIL), and thoracic duct cell depletion by continuous centrifugation to determine the effects of lymphocyte depletion on primary and secondary antibody responses to tetanus toxoid. These procedures induced a severe depletion of small lymphocytes in circulating blood and thoracic duct lymph. Although the appearance of detectable serum antibody was delayed 5 to 10 days and peak titers were slightly reduced, all calves depleted of circulating lymphocytes gave nearly normal primary tetanus antitoxin responses. Repetitive ECIB to 250 to 860 blood volumes during a period of 10 to 30 days with accumulated radiation doses of 93,000 to 250,000 rads failed to significantly repress secondary responses to fluid tetanus toxoid. These findings are in sharp contrast to the well-known radiosensitivity of antibody responses when total doses of 50 to 600 rads of ionizing radiation are delivered by whole-body exposure prior to immunization. (auth)

**20371** THE EFFECT OF IONIZING RADIATION ON THE HISTOCHEMICALLY DEMONSTRABLE GLYCOGEN CONTENT OF THE GUINEA-PIG RETINA DURING INHALATION OF NORMOBARIC AIR OR HYPERBARIC OXYGEN (3 ATM). Franke, H. D.; Lierse, W. (Univ., Hamburg-Eppendorf, Ger.). Ger. Med. Mon., 13: 289-91(June 1968).

In a hyperbaric steel chamber guinea pigs weighing 350 g were exposed to megavoltage x radiation (17 MeV) from a betatron. Radiation was given in 1 dose of 500, 1000, or 2000 rad. The glycogen concentration within the glial cells of the retina was increased after 500 rad, while in the ganglion cells this effect was not observed after 500 rad. After 1000 rad the glycogen content in the end-feet of the glial cells and in the ganglion cells of the third neuron was decreased, as it was also in the outer nuclear layer (first neuron). The degree of reaction corresponded to about that after 2000 rad in air at atmospheric pressure. In addition, there were blister-like bulgings with separation of the limiting membrane after exposure to 1000 rad at 3 atm of oxygen. On exposure to 2000 rad in oxygen, all reactions were again increased, spreading from the center of the retina towards the periphery and involving larger areas. In the control animals which had been exposed only to hyperbaric oxygen without irradiation there were no differences from the other animals in the retina. In cerebral tissue there was no increase in tissue reaction after irradiation in an hyperbaric atmosphere. These results showed a doubling of tissue reaction in the retina under hyperbaric oxygen. The histochemically demonstrable blocking of carbohydrate metabolism at higher dose levels may constitute irreversible damage to the individual cells. (BBB)

**20372** CHANGES OF ERYTHROPOIESIS AND IRON METABOLISM AFTER IRRADIATION. Hodgson, George; Eskuche, Irma (Univ. de Chile, Santiago). Arch. Biol. Med. Exp., 4: 282-6 (1967). (In Spanish).

Male rats were subjected to $^{137}Cs$ γ irradiation to whole-body doses of 100 to 500 rad and were injected with $^{59}Fe$ to test iron uptake by erythropoietic components. An increase in iron uptake by femur over that of nonirradiated controls was observed in rats irradiated 200 rad, after a course of phenylhydrazine treatment. This was shown to represent a shift in iron uptake from the peripheral blood to the marrow. This shift is discussed in relation to marrow population pressure. Ineffective erythropoiesis was not involved. A one-to-one relation was found between: (1) iron uptake by erythroid tissue calculated as the product of plasma iron turnover and the fraction of $^{59}Fe$ in red cells at 48 hr and (2) iron uptake calculated from the 4-hr $^{59}Fe$ distribution assay. Plasma iron concentration increased as iron uptake by erythroid tissue decreased as a consequence of irradiation. The slope of the line relating these 2 variables was smaller the higher the initial iron uptake. Iron uptake by liver increased as function of plasma iron concentration to stabilize at maximum value at about 4 to 5 μg/ml. The uptake of other nonerythroid tissues, presumably intestine, rose at first, but then dropped dramatically, possibly as a consequence of cell death due to irradiation. (BBB)

**20373** INCORPORATION AND RELEASE OF $^{85}Sr$ AND $^{14}C$-PROLINE-HYDROXYPROLINE IN MINERAL AND COLLAGEN OF BONE AND INCISOR TEETH OF GROWING RATS. Bauer, Goeren C. H.; Shtacher, Gad (Hospital for Special Surgery, New York). Calcified Tissue Res., 2: 106-10(July 1968).

The extent to which exchange and reutilization processes of mineral tracers affect skeletal mineral accretion and resorption measurements was evaluated by comparing the rates of appearance and disappearance of $^{85}Sr$ and $^{14}C$-proline-hydroxyproline in bones and teeth. Expressions for the relative rates of collagen synthesis and breakdown, which unlike mineral metabolism are considered not to be complicated by exchange phenomena, were based on $^{14}C$-proline conversion to $^{14}C$-hydroxyproline; the sp act. of the latter was determined. Both the mineral and the collagen sp act. reflected the rates and patterns of growth of the samples assayed, that is, rapid growth and a short interval of time between formation and resorption of tissue in the metaphyseal bone which contains the cartilaginous growth plate, slow growth and an interval of time between formation and resorption of tissue in diaphyseal bone and incisor teeth which is longer than the 12 days of the experiment. However, in metaphyseal bone the sp act. collagen/mineral ratio dropped by one half during the 4 to 12 day interval in contrast to diaphyseal bone and incisor teeth in which no change in this ratio was observed during this period of time. The data indicated that collagen in the metaphyseal growth zone is removed by resorption before it has become fully mineralized, and that exchange is a relatively unimportant factor in the long-term kinetics of bone mineral. (BBB)

**20374** MORPHOLOGICAL AND FUNCTIONAL CHANGES IN THE RABBIT EYE ON EXPOSURE OF THE DORSAL BULB SECTION TO BETA RAYS ($^{106}Ru/^{106}Rh$). Lommatzsch, P. (Humboldt-Univ., Berlin). Arch. Klin. Exp. Ophthalmol., 176: 100-25(Oct. 4, 1968). (In German).

Histologic and electroretinographic (ERG) changes in the rabbit eye exposed to the 3.53-MeV β radiation from $^{106}Ru/^{106}Rh$ were observed. The dorsal part of the eye was irradiated with doses ranging between 2000 and 500,000 rad. After exposure to 20,000 rad, sharply limited changes could be detected in the fundus. Doses of 10,000 to 20,000 rad produced damage to the visual cells. The most radiosensitive parts were the outer and inner segments as well as the outer nuclear layer. After exposure to 50,000 to 100,000 rad all cells including the large ganglious cells were destroyed. After doses higher than 20,000 rad a reduction of the b-wave amplitude of the ERG could be found. To study the influence of irradiation on the ERG, additional experiments were made on the isolated rabbit retina. An exposure to 10,000 rad surface dose resulted in a reduction of the b-wave. After 20,000 rad edema of the choroid was seen as an immediate reaction and a complete choroid atrophy as a late effect. Even after such high doses as 500,000 rad, never was perforation of the bulb seen, although radiogenic necroses of the sclera developed. These results showed that it is possible to apply very high doses of β radiation to a part of the bulb without causing radiogenic destruction of the whole bulb. There is a sharp boundary between the radionecrosis and normal tissue, which may be of practical value for the treatment of tumors of the eye by β irradiators. (BBB)

**20375** RADIOSENSITIVITY AND BIOLOGICAL PROPERTIES OF TUMORS. XIV. CORRELATION BETWEEN MITOCHONDRIAL STRUCTURE, OXIDATIVE METABOLISM, AND RADIO-

SENSITIVITY. Goldfeder, Anna; Selig, Joseph N. (New York Univ., N. Y.). Radiat. Res., 37: 499-524(Mar. 1969).

Our previous observations that x irradiation induced profound changes in cytoplasmic ultrastructures have been extended. Parallel investigations on four types of mouse tumors (IBAH, DBAG, Adj-PC-5, DBrB), differing in growth rates, were carried out in respect to the ultrastructural integrity of their mitochondria, their ability to carry out oxidative metabolism, and their response to x irradiation. Mitochondria of the most rapidly proliferating DBAG and DBrB tumors possessed the lowest oxidative and phosphorylative capacities as determined by P:O ratios. The mitochondria of these tumors were few in number and of inferior quality, as deduced from electron micrographs. The P:O values of liver and kidney were significantly higher than those of the tumors, corresponding to the superior quality and quantity of mitochondria. Similarly, the ATP, HMP, and cytochrome oxidase levels were also significantly lower in the tumors than in the livers and kidneys. Exposures to 3000 R induced extensive swelling of mitochondria, breakages of their cristae, and dilatation of vesicles of the endoplasmic reticulum in the tumor cells. Conversely, exposures up to 10,000 R failed to induce significant effects on the mitochondrial oxidative metabolism of the tumors. On the basis of electron microscopic findings, it is inferred that the intrinsic quality of the cytoplasmic constituents, including mitochondria, plays a greater role in cellular radiosensitivity than the metabolic events. (auth)

**20376** THE EFFECTS OF X-RADIATION ON THYMIDINE-LABELED DNA OF REGENERATING RAT LIVER. Looney, William B.; Chang, Lillie O. (Univ. of Virginia, Charlottesville). Radiat. Res., 37: 525-30(Mar. 1969).

The local irradiation of regenerating liver 1 hour after the administration of tritiated thymidine revealed no loss of labeled DNA after 3000 R and 6000 R of x-radiation. This is six to twelve times the $D_{37}$ dose (500 R) of the initial radiosensitive component of the biphasic dose response found for the reduction of DNA synthesis following irradiation. The reduction of both autoradiographic and biochemical results to approximately 80% of control values after 12,000 R, in two independent experiments, suggests that thymidine-labeled-DNA degradation may be beginning to occur at this dose. The extensive degradation of DNA found in Escherichia coli (up to 50%) has not been found in mammalian cells, either in vivo or in vitro. Differences in repair mechanisms, or differences in the status of the DNA, may be the reasons for the differences in degrees of DNA degradation found after irradiation in bacterial and mammalian cells. Therefore, the present experimental results fail to substantiate the hypothesis that substantial degradation of DNA occurs in mammalian cells in the radiation dose range which results in a significant depression of the rate of DNA synthesis. (auth)

**20377** THE EFFECT OF RADIOPROTECTIVE AGENTS ON STEM CELL RECOVERY AFTER IRRADIATION. Vittorio, P. V.; Dziubalo-Blehm, S.; Amey, E. A. (Biological and Radiation Establishment, Ottawa). Radiat. Res., 37: 653-64(Mar. 1969).

Erythropoietic stem cell damage and recovery after treatment with radio-protective agents followed by gamma irradiation was measured in transfusion-induced polycythemic mice in conjunction with $^{59}Fe$ red cell incorporation as the indicator of erythropoietic activity. In irradiated mice, the administration of S-2 aminoethylisothioureadihydrobromide (AET) prior to irradiation results in less initial damage to the blood and spleen, and this is responsible for the earlier recovery of the erythropoietic system. Blood and spleen $^{59}Fe$ values at 1 or 7 days after irradiation with 200 or 700 rads, respectively, can be used to compare the relative value of different sulfhydryl agents in aiding survival. Using the split-dose technique, it was shown that AET given prior to the second radiation dose provided protection to the hematopoietic system and increased survival. However, AET prior to the first radiation dose (200 rads) did not produce any increased protective effect over that produced by the first radiation dose when the mice were irradiated 10 days later. (auth)

**20378** A METHOD FOR DETERMINING RESIDUAL INJURY IN THE HEMATOPOIETIC SYSTEM OF THE X-IRRADIATED RAT. Gong, J. K.; MacVittie, T. J.; Vertalino, J. E. (State Univ. of New York, Buffalo). Contract AT(30-1)-3728. Radiat. Res., 37: 467-77(Mar. 1969).

A method was introduced to document the progressive changes in the ability of rat skeletal marrow to respond to bleeding over a span of 60 weeks following a single sublethal whole-body x-ray dose. Rats were exposed to a 170-R (200-kVp x-ray) whole-body dose. At intervals of 3, 6, 7, 10, 25, 33, 40, and 60 weeks postirradiation, half of each of the x-irradiated and control groups was bled one-third or two-thirds of the calculated blood volume (cbv) each, and their overall skeletal marrow content of nucleated RBC was determined. The remainder of the x-irradiated and control animals were measured for total marrow content of nucleated RBC without bleeding. The increase in RBC precursors on bleeding in the x-irradiated animal was compared with that found in the control animal on bleeding. This ratio (x-irradiated RBC precursor increase ÷ control RBC precursor increase) constitutes the "erythroid response index" (ERI) and is expressed as a percentage. An ERI value of 100% is taken to mean a lack of residual injury. Any value of ERI less than 100% would then be the percentage of residual injury (residual injury (%) = 100% − ERI). When the residual injury was calculated for the various times studied and plotted, a simple negative exponential function was found between 7 and 60 weeks postirradiation. The loss of residual injury measured in this manner was found to have a half-time of 29.2 weeks. (auth)

**20379** EFFECT OF METHYLCELLULOSE ON CATABOLIC PROCESSES IN NORMAL AND IRRADIATED GUINEA PIG SPLEEN. Babnik, J.; Lebez, D. (Nuclear Inst. Jozef Stefan, Ljubljana, Yugoslavia). Int. Z. Angew. Physiol., 26: 330-4 (Nov. 4, 1968).

Catheptic activity and metabolic nitrogen was measured in guinea pigs treated with methylcellulose, which induced hypersplenism. It was found that both parameters varied differently in methylcellulose-treated animals as in controls. Guinea pig spleen treated with methylcellulose behaved differently from rat spleen treated in the same way. In the spleen perfusate of nonirradiated, methylcellulose-treated guinea pigs, total nitrogen was increased only by 36% in comparison with the nonirradiated controls. Nonprotein nitrogen was increased more than protein nitrogen. Three hr after 600-R irradiation nitrogen level was decreased in methylcellulose-treated guinea pigs and reached the level of the nonirradiated controls. In irradiated control animals the excretion of nitrogen was increased, whereas it was decreased in methylcellulose animals. After irradiation protein nitrogen was decreased when compared with the nonirradiated controls. On the contrary, nonprotein nitrogen was high in nonirradiated controls. In the ninth hour after irradiation no difference was observed in the nitrogen excretion in the 2 groups of animals. Catheptic activity determined in spleen homogenates varied similarly as nonprotein nitrogen. (BBB)

**20380** RADIATION BREEDING OF THE DOMESTIC FOWLS. 2. THE EFFECTS OF LONG-TIME IRRADIATION OF GAMMA RAYS ($^{60}Co$) ON CHICK GROWTH AND EGG PRODUCTION. Kashiwabara, Takao; Tanaka, Ryoichi (Ibaraki Univ., Japan). Ibaraki Daigaku Nogakubu Gakujutsu Hokoku, No. 15, 33-41(Oct. 1967) (In Japanese).

Experiments designed to study lethal dose and dose rate on radiation breeding of domestic fowls are reported. Dose rates (R/day) rather than total dose had an important part in the lethal effects on domestic fowls in the long time γ irradiation. Threshold dose rate in this experiment was 33 R/day. A dose of 66 R/day showed 100 percent lethality for four-month old chicks at cumulative total doses of 2,000 R to 3,000 R. Male growth rate differed from female growth rate in these experiments. Sexual maturity was accelerated in the 250 to 500 R dose range of both breeds. Laying intensity was increased in the 500 to 1,000 R of the New Hampshire breed. Optimal doses for radiation breeding of the domestic fowls were concluded to be 500 R for male stocks and 1,000 R for female stocks. (TSS) (NSA of Japan)

**20381** EFFECTS OF RADIATION AND ETHIONINE ON RAT MAMMARY TUMOR INCIDENCE. Telles, Norman C.; Ward, Billy C. Radiat. Res., 37: 577-89(Mar. 1969).

A single, sublethal dose of x radiation (175 RADS) to the whole body or liver of Osborn–Mendel female rats fed dl-ethionine for 5½ months has resulted in an increased incidence of rats with mammary tumors in the whole-body irradiated but not in the liver-irradiated or control rats. This increase appears to be related to the dietary level of ethionine. It was not apparent until at least 6 months after ethionine was removed from the diet. Incidence of mammary tumors for control and liver-irradiated rats was unchanged or slightly reduced with ethionine. (auth)

**20382** ALTERATIONS IN BLOOD VESSELS IN X-IRRADIATED SPINAL CORDS OF YOUNG RATS. Gilmore, Shirley Ann (Univ. of Arkansas Medical Center, Little Rock). Anat. Rec., 163: 89-100(Jan. 1969).

X irradiation (4000 R) of lumbar spinal cords of 3-day-old rats caused a loss of neuroglia with an inhibition of myelinogenesis, neuronal damage, and necrosis. In contrast, the loss of neuroglia following 2000 R was temporary, with myelinogenesis occurring later than normal. Differences in vascular responses to these two doses might account for these differing fates of the spinal cords; therefore, this investigation was designed to study further the re-

actions of the intramedullary vessels. Rats irradiated when 3 days of age, were killed 1 to 27 days later. Some were killed by perfusion with Monolite Fast Blue BNVSA Paste, a substance retained in the vessels and readily visualized on microscopic examination. The remaining rats were decapitated, and spinal cords were strained. The earliest consistent alteration, a decreased number of vessels, was noted 7 days following irradiation with either dose. Rats receiving 4000 R had marked losses of blood vessels, vasodilatation, and necrosis by 15 days postirradiation, whereas, a decreased number of vessels was the only change noted in rats irradiated with 2000 R. Alterations in rats receiving 4000 R remained the same or became more severe throughout the study; spinal cords in rats receiving 2000 R returned to normal. These vascular alterations correlated well with the changes in other spinal cord components described previously. (BBB)

**20383** EXPERIMENTAL INFECTION WITH THE VIRUS OF LYMPHOCYTIC CHORIOMENINGITIS OF X-IRRADIATED MICE. Danes, L.; Blazek, K. (Military Inst. of Hygiene, Epidemiology, and Microbiology, Prague). J. Hyg. Epidemiol. Microbiol. Immunol., 11: 400-7(1967).

The effect of whole-body x radiation (250, 300, and 350 R) on the manifestation of the disease was studied in mice infected intracerebrally with the strains WE and Kucharikova of the lymphocytic choriomeningitis (LCM) virus. Irradiation performed prior to infection protected the mice significantly from the development of symptoms and from death. The susceptibility of the irradiated mice returned to normal in a course parallel to the normalization of the white blood cell count. If performed after the virus inoculation, the irradiation lost its protective effect. Local 800 R irradiation of the head prior to infection prevented the development of infiltration of meninges and plexuses; it did not, however, protect the mice from death. The results in the total-body irradiated and locally irradiated mice indicated that the central nervous system (CNS) infiltration alone is not of decisive importance for the manifestation of the disease. Probably the fatal development of LCM infection in locally irradiated mice must be attributed to the preservation of the white blood cells and their formation as well as to pathological changes in other organs than the CNS. Earlier findings as well as these results yielded an indirect proof of the role of leukocytes in the pathogenesis of experimental infection of mice with the LCM virus. (BBB)

**20384** EXERCISE PERFORMANCE OF UPPER-BODY X-IRRADIATED DOGS. Martin, Barbara A.; Michaelson, Sol M. (Univ. of Rochester, N. Y.). Contract W-7401-eng-49. Amer. J. Physiol., 211: 457-61(Aug. 1966). (UR-49-706).

Exercise performance of upper-body x-irradiated dogs during the acute and early chronic phases of radiation injury was investigated. Seven mongrel dogs of both sexes were exercised on a motor-driven treadmill at 2.2 mph on a 0% grade. Five dogs were bilaterally exposed to 1,800 R midline air dose (MAD) of 1,000 kvp x rays, at a dose rate of 58 R/min. Two dogs were sham irradiated. Comparisons were made of performances in pre- and postexposure exercise trials. Data were collected on body weight, arterial oxygen saturation, heart rate, rectal temperature, and hematology. With exercise of the intensity and duration used in the present study, upper-body x-irradiated dogs appeared able to maintain a level of physical performance comparable to their preexposure capabilities until about two months after radiation. At this point, a diminution in performance capacity appeared, as indicated by the increase in resting heart rate, the inability of the heart rate to properly adjust to the demands of exercise, and one instance of collapse. It was concluded that this exercise had become stressful after radiation. (auth)

**20385** TUMOR TISSUE STRUCTURE AND RADIOSENSITIVITY. 1. TUMOR OF SIMPLE STRUCTURE. Niibe, Hideo; Tobe, Tatsuo (Gunma Univ., Japan). Nippon Igaku Hoshasen Gakki Zasshi, 28: 1256-64(Dec. 1968).

Relation between tumor tissue structure and radiosensitivity was investigated with Yoshida sarcoma in rats and MC-induced sarcoma in mice. The results were as follows: Mitotic potency was higher in tumor cells which grew adjacent to blood vessel and muscle, but low in those which were remote from them. This was true almost regardless of days after transplantation and size of tumor. However, when the tumor is large, cells not adjacent to muscle and blood vessels are increased, reducing as the result the relative number of those adjacent to them. Radiosensitivity was high in the cell group with vigorous mitosis, and low in the group with suppressed mitosis. In general, the part showing vigorous mitosis was well supplied with oxygen. Thus, vigorous mitosis was not the only determinant of radiosensitivity. Mitotic potency of Yoshida sarcoma was reduced when it was kept at low temperatures. It was also suppressed in the early period after subcutaneous transplantation. In both cases, radiosensitivity was also lowered. Some clinical cases showed that the cell groups adjacent to blood vessels and muscles were very radiosensitive. (auth)

**20386** STUDIES ON LD50/30 OF MICE BY SIEVE IRRADIATION GIVEN IN 1 TO 16 EQUAL FRACTIONS. Kickawa, Sumihiro (Kyoto Prefecture Univ.). Nippon Igaku Hoshasen Gakki Zasshi, 28: 1211-21(Dec. 1968). (In Japanese).

It is well known that the sieve effect is proportional to the inhomogeneity quotient (IQ) and has a negative correlation with the size of the radiation field. However, most published data are based on single exposure studies and it is not known how the dose fractions influence the sieve effect. Here, the relationship between the biological sieve effect ratio (BSER) and the number of fractions (1, 2, 4, 8 and 16) was studied by evaluating the LD50/30 of the mouse after whole body x irradiation with or without a sieve. 1239 male mice of ddYF strain (eight weeks old and 25 ± 3 g in body weight) were used in the experiment. A Toshiba KXC-18 type x-ray unit was operated at 200KV, 25 mA. H.V.L. was 0.8 mm Cu and FSD was 40 cm. Dose rate at 1 cm depth was 155 rads/min. without a sieve and 65 rads/min. with a sieve. The sieve was made of a sheet of lead 2 mm thick with open circles of 3 mm in diameter. The open area ratio was 40% and IQ in 1 cm depth was 4.0. The LD50/30 by conventional homogeneous irradiation given in the number of 1, 2, 4, 8 and 16 were 626, 772, 835, 990 and 1344 rads, and those by sieve irradiation given in the same number of fractions were 749, 907, 992, 1168 and 1514 rads, respectively. These values coincided well with the theoretical data calculated by a multi-target formula assuming that LD50/30 caused the bone marrow death of the animals and bone marrow cells have the radiosensitivity reported by Till and McCulloch. The BSER, i.e., the ratio of LD50/30 by irradiation through a sieve versus LD50/30 by the conventional method, for each fractionated irradiation of 1, 2, 4, 8 and 16 were 1.196, 1.175, 1.188, 1.180 and 1.126, respectively. They did not differ significantly. Therefore, it would be considered that the sieve effect remains throughout the fractionated irradiation. (auth)

**20387** EFFECTS OF $^{90}Sr$ AND $^{137}Cs$ ADMINISTERED CONTINUOUSLY AND THROUGH GENERATIONS UPON MICE. Nishio, Kazuo; Megumi, Tsuneo (Radiation Center of Osaka Prefecture). Hoken Butsuri, 3: 393-401(Dec. 1968). (In Japanese).

Mice of NA-2 strain were treated continuously and through generations with $^{90}Sr$ and $^{137}Cs$ contained in drinking water. Concentration of the isotopes was divided into three levels; Group I: ($^{90}Sr$ 0.1 $\mu$Ci and $^{137}Cs$ 0.4 $\mu$Ci)/ml, Group II: (0.01 and 0.04 $\mu$Ci)/ml, Group III: (0.001 and 0.004 $\mu$Ci)/ml, and Group IV (Control) was fed with noncontaminated water. Abnormality of growth, life-span and reproduction in these groups were summed up until the tenth generation. Group I showed a shortening of the life-span and absence of reproductive function as early as the second generation. Group II showed injury to growth and reproduction and a shortening of the life-span, but proceeded to subsequent generations. In Group III no injury was noted as in Groups I and II, but there appeared to be an increase in reproductive function and a lengthening of the life-span. It can be concluded that Groups I and II were in a state of radiation injury, but Group III was in some excited state by $^{90}Sr$ and $^{137}Cs$. Another remarkable character of Group III was that tolerance against whole-body irradiation of 700 R was aquired not by genetic mutation or selection but by the effect of the isotopes after birth and the tolerance was more intense in female than in male mice. This tendency was found also in Group II, but the tolerance was weaker. (auth)

**20388** EXPERIMENTAL BONE MARROW FIBROSIS IN RATS AFTER SUBLETHAL WHOLE-BODY X IRRADIATION AND BONE MARROW TRANSFUSION AS A MODEL OF HUMAN MYELOFIBROSIS. Stodtmeister, R.; Becker, H.; Cronkite, E. P.; Fliedner, T. M.; Messner, H. (Univ., Ulm, Ger.). Schweiz. Med. Wochensch., 98: 1671-3(Oct. 19, 1968). (In German).

Myelofibrosis was frequently observed among 700 rats that received an injection of 0.6 to $1.0 \times 10^8$ allogenic bone marrow cells immediately after exposure to 750 R of x radiation dose. Both Wistar and Sprague–Dawley strains were used. The evaluation of bone marrow histology of rats sacrificed at specified times after irradiation and of those that died spontaneously indicated the presence of myelofibrotic or myelosclerotic marrow changes. Intensive study of the fibrotic bone marrow sections showed a high degree of similarity of the findings with the various stages of myelofibrosis as seen in human beings. Of the 213 rats that died during the first 14 days after radiation exposure, 12 (5.6%) showed myelofibrosis, while in the rats sacrificed no fibrosis was found. Of the 72 rats that died between day 15 and 40 after irradiation 19 (26.4%) showed myelofibrosis, compared with 6.2% of the 32 sacrificed animals of this phase. Of the 45 rats that died between day

41 and 120 after exposure 13.3% were fibrotic, against 7.1% of the 127 rats sacrificed. From the myelofibrotic and osteomyelosclerotic bone marrows it appeared possible to reconstruct the development of this lesion. It is concluded that myelofibrosis may develop as a consequence of immunological reactions. Intercurrent bacterial or viral infections may have augmented the rejection process. (BBB)

**20389** SOME ULTRASTRUCTURAL ASPECTS OF RADIATION-INDUCED CYTONECROSIS. Vsevolodov, E. B.; Prusova, L. S. (Inst. of Experimental Biology, Alma-Ata, USSR). Izv. Akad. Nauk Kaz. SSR, Ser. Biol., 5: 79-84(Sept.-Oct. 1967). (In Russian).

Rams received a total radiation dose of 500 R focused on the testes; rabbits were exposed to 700 R also to the testes. Tissue biopsies for microscopic examinations were performed 6 and 26 hr after irradiation. Cytonecrosis appeared in testes as early as 5 hr after irradiation and their developmental stages were studied further, including later changes developed up to 26 hr after exposure. The progressive findings in radionecroses included: concentrations of chromatin (karyosomes) under testicular membranes, interference of congested chromatin sectors in other contents of nuclei; emergence of formed granules of congested chromatin into cytoplasm with a preservation of obliterated nuclei; progressive depolymerization of DNA in a granule with its stratification into feulgen-positive and pyroninophylic types; decongestion of the feulgen-positive part of granule until its complete disappearance; hydrolysis of granules and shriveling; and hydrolysis of nucleic remnants. (BBB)

**20390** EFFECTS OF LARGE DOSES OF ORALLY INGESTED $^{90}Sr$ ON YOUNG CATTLE. Cragle, R. G.; Stone, W. H.; Bacon, J. A.; Wykoff, M. H. (Univ. of Tennessee, Oak Ridge. Univ. of Wisconsin, Madison). Radiat. Res., 37: 415-22(Feb. 1969).

Six young female dairy animals between the ages of 398 and 479 days were given $^{90}Sr$ orally for five days in the amount of 44 $\mu$Ci per day per kilogram of body weight. Four of these animals died from 93 to 132 days after treatment, and two are survivors at three years after treatment. An average of 41.8% of the $^{90}Sr$ dose was retained at 11 days after initiation of treatment, and an average of 8% was estimated as retained in the skeletons of the four animals at the time of death. Death was attributed to radiation, since the typical radiation syndrome was exhibited. An average of less than 1% was estimated to be in the skeletons of the two survivors as determined from bone biopsies at 321 days after initiation of treatment. (auth)

**20391** LOW-DOSE X-RAY EFFECTS ON THE PRECLEAVAGE MAMMALIAN ZYGOTE. Rugh, Roberts; Wohlfromm, Marlis; Varma, Andre (Columbia Univ., New York). Contract AT(30-1)-2740. Radiat. Res., 37: 401-14(Feb. 1969).

By limiting the mating time of CF1 and CF1-S mice to a period of 40 to 45 minutes, zygotes could be exposed to x-ray doses of 10, 15, 25, and 50 R at various ages. Sixty groups of 50 mice each, were x-irradiated at different times from one to 12 hr, 18, 24, and 30 hr after insemination, at each of the dose levels, to determine the effect of these low doses on the preimplantation stages of the zygote. A total of 34,804 x-irradiated and 9950 control implantations were examined at the eighteenth day of gestation and classified as resorbed, dead, anomalous, or apparently normal. There was a statistically significant reduction in the number of implantations when 50 R was applied to the six to eight-hour-old zygotes. There was a reduction in implantations for the same age group x-irradiated at 25 R. The percentage of apparently normal live fetuses among the implantations at the eighteenth day of gestation was used as the basic variable. There was a significant decrease in the percentage of normal implantations at the age of seven hr in the 10-R series; six, seven, and eight hr in the 15-R series; at five, six, seven, eight, nine, and 10 hr in the 25-R series; at two to 11 hr and 18 hr in the 50-R series. The difference must be attributed to increases in resorptions and early deaths. Thus, even the relatively low levels of x-ray exposure prior to cleavage resulted in a significant increase in early fetal loss. (auth)

**20392** REPOPULATION OF IRRADIATED LYMPH NODES BY RECIRCULATING LYMPHOCYTES. Benninghoff, D. L.; Tyler, R. W.; Everett, N. B. (Univ. of Washington, Seattle). Radiat. Res., 37: 381-400(Feb. 1969).

The effects of local versus total-body irradiation of lymph nodes were compared in rats in which the long-lived lymphocytes had been labeled with tritiated thymidine (TTH) prior to irradiation. Three parameters of the lymph nodes were compared after the irradiation namely: quantitative cell depletion, histologic evidence of radiation damage, and percentage of lymphocytes labeled with TTH shown in radioautographs. Following equal doses of 300 rads, the cervical lymph nodes given local irradiation were not significantly depleted of cells, while the cervical nodes included in total-body irradiation were severely depleted of cells. Histologic evidence of cell death was seen in both the local and total-body-irradiated nodes. The percentage of lymphocytes labeled with TTH in the locally irradiated nodes, both at two days and at 14 days after irradiation, was the same as in the animal's unirradiated mesenteric nodes and in the cervical nodes of the control animals. The steadfast percentage of labeled lymphocytes, observed in the locally irradiated nodes at the same time that cell numbers were unchanged and that cell destruction was evident, demonstrated that cell depletion after local radiation of the lymph nodes was counterbalanced by entry of lymphocytes into the nodes from the recirculating pool. Up to two weeks following total-body irradiation there was no evidence of quantitative cell recovery of the long-lived lymphocyte pool. (auth)

**20393** OXIDATIVE PHOSPHORYLATION IN SPINAL CORD OF INTACT AND IRRADIATED ANIMALS. Dvoretskii, A. I.; Reva, A. D. (State Univ., Dnepropetrovsk, USSR). Ukr. Biokhim. Zh., 40: 508-13(1968). (In Ukrainian).

Oxidative phosphorylation was investigated in the whole lumbar spinal cord of cats as well as in its different regions (grey matter of anterior and dorsal horns and in white matter). The level of phosphorylation and oxidation in the spinal cord was shown to be different when using glutamic, $\alpha$-ketoglutaric and succinic acids as oxidation substrates. The most intensive succinic acid oxidation was in the grey matter of the anterior horns, somewhat weaker in the grey matter of the dorsal horns and still weaker in the white matter. A single total x-ray irradiation of the animal with a dose of 1200 R caused in five days an essential inhibition of oxidation and phosphorylation and their conjugation in the tissues of the grey matter of the anterior horn, dorsal horn and in the white matter of lumbar enlargement if their intensity was determined on a depleted incubation medium in $\alpha$-ketoglutarate oxidation. In all the cord regions under investigation phosphorylation was inhibited to a greater extent than oxidation. (auth)

**20394** APPARATUS FOR ADMINISTRATION OF GASEOUS $^{14}CO_2$ TO SMALL ANIMALS. Joftes, David L. (New England Deaconess Hospital, Boston). Int. J. Appl. Radiat. Isotop., 20: 157-65(Mar. 1969).

It is well known that $^{14}C$-labeled inorganic compounds acutely administered have a very short biological half-life. Nearly all the $^{14}C$ is breathed off as $^{14}CO_2$ in a few hours. In order to study the possible effects of the increased availability of $^{14}C$ in the biosphere on spermatogenesis, two controlled environment chambers were constructed. Using these chambers it was possible to circumvent the short residence time and to expose mice for long periods to an atmosphere containing $^{14}CO_2$ in one chamber, and to a control atmosphere containing the same amount of $^{12}CO_2$ in the other chamber. The $^{12}C$ enters the organism via the blood carbonate pool and under these conditions remains long enough to become available for synthesis by known (and perhaps some unknown) pathways. The construction of the chambers and their control systems, as well as the necessary safety precautions, are described. Increases in the $^{14}C$ content of tissues of exposed animals versus the tissues of control animals were detected by liquid scintillation counting. Other radioactive gases or aerosols could be substituted for the $^{14}CO_2$ if they are available in pressure tanks or could be generated within the chambers for use in other investigations. (auth) (UK)

**20395** CORNEAL DAMAGE THRESHOLDS FOR $CO_2$ LASER RADIATION. Peppers, N. A.; Vassiliadis, A.; Dedrick, K. G.; Chang, H.; Peabody, R. R.; Rose, H.; Zweng, H. C. (Stanford Research Inst., Menlo Park, Calif.). Appl. Opt., 8: 377-81 (Feb. 1969).

A gaussian beam from a $CO_2$ laser emitting at 10.6 $\mu$ was used to measure damage thresholds on rabbit cornea at exposure times of 55 msec, 10 msec, and 3.5 msec. A theoretical model of the radiation–tissue interaction is presented and compared with experimental data. The comparison suggests that a critical temperature exists above which lesions are caused by protein denaturation. The model is useful for establishing safe exposure levels within a limited exposure range. (auth)

**20396** CHANGES IN ELECTROCONVULSIVE THRESHOLDS AND PATTERNS IN RATS AFTER X-RAY AND HIGH-ENERGY PROTON IRRADIATION. Sherwood, N. M.; Welch, G. P.; Timiras, P. S. (Univ. of California, Berkeley). Contract AT(11-1)-34. Radiat. Res., 30: 374-90(1967). (UCB-34P82-132).

Electroshock seizure threshold and pattern were altered after x irradiation or proton irradiation of rats. Radiation acted both directly (after head irradiation) and indirectly (through peripheral damage after body-alone irradiation) to lower the electroshock seizure threshold during the early postirradiation period. It acted

only in a direct manner thereafter. Increased susceptibility to seizures, as demonstrated by a reduction of threshold, occurred after doses of 450 or 950 R directed to the head, body only, or whole body, or after 500 to 10,000 rads of protons directed to the head. Seizure intensity, as indicated by the maximal seizure pattern, increased after 500 rads of protons, but decreased after 5000 or 10,000 rads of irradiation to the head. Radiation appears to be excitatory at the lower doses used in the present experiment in regard to both seizure initiation and maintenance, but to be anticonvulsant at higher doses in regard to seizure maintenance. (auth)

**20397** EXPERIMENTAL ANIMAL STUDIES OF THE EFFECT ON THE BLOOD PICTURE CAUSED BY TELERADIOTHERAPY OF THE SKIN. Betetto, M. (Univ. Skin Clinic, Ljubljana, Yugoslavia). Hautarzt, 19: 367-71(Aug. 1968). (In German).

Results are reported of x irradiation of guinea pigs with fractionated doses unfiltered soft x rays and with conventional x rays at a rate of 450 R/week. There was a steep drop in blood cell count in the animals given conventional x rays, and the animals died within 5 weeks of continued treatment. The animals that were irradiated with the soft x rays were alive after 40 weeks of irradiation. The blood cell counts did not decrease below a physiologically critical level, but were lower than in control animals, indicating some irradiation injury. No skin injuries were observed in the animals that died after the conventional x irradiations, but in the animals that received soft x rays erythematous, scaly epilation appeared after 30 weeks of irradiation. Some skin erosions were observed. Weight losses were nc observed in this group, although the conventionally x irradiated animals lost considerable weight. (BBB)

**20398** BENZOYL-GLYCINE CONJUGATION AFTER WHOLE-BODY IRRADIATION. Souto, Jose; Coffee, Carole J. (Univ. of Tennessee, Oak Ridge). Contract AT(40-1)-GEN-242. Int. J. Radiat. Biol., 14: 427-35(Dec. 1968).

Urinary excretion of benzoyl-glycine was increased after whole-body $\gamma$ irradiation of rats, sheep and pigs maintained on a constant daily food intake. The increase occurred in the rat and sheep in the third and fourth week, and in the pig in the third to sixth weeks. In rats submitted to audiogenic stress there was no increased excretion of benzoyl-glycine. Creatinine excretion was not changed after whole-body irradiation or stress in the three species. Uric acid output was decreased in the rat between days three and 10 after irradiation or after stress, and for the pig and sheep between days one and seven after irradiation. The data are indicative of changes produced by ionizing radiation in the conjugation of glycine with benzoic acid. (auth)

**20399** FURTHER STUDIES ON PLASMA TRANSAMINASE OF IRRADIATED MICE. Barnes, J. H. (Medical Research Council, Harwell, Eng.); Lowman, Doreen M. R.; Bautista, S. C.; De La Cruz, B.; Lansangan, Lili. Int. J. Radiat. Biol., 14: 417-25(Dec. 1968).

In two strains of mice, plasma glutamic-oxalacetic transaminase (GOT) was elevated six hours after whole-body x irradiation. In Harwell R mice the response varied linearly with dose from 0 to 1000 rads, but showed evidence of saturation at a higher dose. In Swiss mice the response became saturated above 500 rads. The response to neutron irradiation in R mice was also linear to 1000 rads. The RBE is about 1.0. The plasma GOT response to a large dose of corticosteroid resembled the response to lethal irradiation. It is probable that lymphoid tissue is the major source of the enzyme. Radioprotectors per se increased plasma GOT in unirradiated R mice by two to 20-fold. (auth)

**20400** RADIOSENSITIVITIES OF CELLS FROM WHICH RADIATION-INDUCED SKIN TUMOURS ARE DERIVED. Hulse, E. V.; Mole, R. H.; Papworth, D. G. (Medical Research Council, Harwell, Eng.). Int. J. Radiat. Biol., 14: 437-44(Dec. 1968).

The observed incidence of epidermal and dermal tumors in mice following superficial external beta irradiation may be accounted for by assuming that tumor induction is proportional to the square of the dose and that potential tumor cells lose their reproductive integrity according to a type C cell survival curve. n = 1.2 and $D_{37}$ = 2440 rads for potential tumor cells of the epidermis and n = 1.9 and $D_{37}$ = 2280 rads for potential tumor cells of the dermis. (auth)

**20401** CHANGES IN THE ELECTRICAL ACTIVITY OF THE OLFACTORY CORTEX INDUCED BY RADIATION AND DRUGS. Timiras, P. S.; Woolley, D. E.; Silva, A. J.; Williams, B. (Univ. of California, Berkeley). Contract AT(11-1)-34. Radiat. Res., 30: 391-403(1967). (UCB-34P82-134).

Electrical activity of the prepyriform (olfactory) cortex was compared in awake, unrestrained rats chronically implanted with electrodes, before and after administration of 250 R or 500 R of whole-body X irradiation and of reserpine, pentobarbital, or pentylenetetrazol. In the prepyriform cortex, the evoked potential elicited by stimulation of the lateral olfactory tract resembles a sinusoidal oscillation, and the spontaneous electrical activity is dominated by fast, sinusoidal waves. X irradiation increased the amplitude of the electrical activity during the first postirradiation week and again one month after irradiation, and shortened the latency between stimulus and response mainly by reducing synaptic delay. In general, the effects of 500 R were either greater or lasted longer than those of 250 R. These observations were interpreted to mean that X irradiation in the doses used had an excitatory effect on the olfactory cortex, and this interpretation was supported by the neuropharmacological data. Reserpine administration to nonirradiated rats decreased amplitude, but the same drug increased amplitude after irradiation. Pentobarbital reduced the number of sinusoidal waves in the evoked response and in the spontaneous activity, whereas a subconvulsant dose of pentylenetetrazol or X irradiation increased the number of these oscillations. (auth)

## *Man*

*Refer also to abstracts 20157, 20233, 20261, 20277, 20279–20281, and 20293.*

**20402** (MIT-952-5(Pt.1), pp 1-136) RADIUM AND MESOTHORIUM TOXICITY IN HUMAN BEINGS. (Massachusetts Inst. of Tech., Cambridge. Dept. of Physics).

Data are summarized on the carcinogenic effects of $^{226}$Ra and its 5.7-yr half-life isotope $^{228}$Ra in man, based on a study of 496 persons observed during a 20-yr period of time. Radiation dose-response relations are presented for a wide variety of parameters, with emphasis on skeletal burdens. Data are also presented from studies on the metabolism of $^{224}$Ra and $^{234}$Th in man; calculations of the $^{226}$Ra and $^{228}$Ra burdens for 82 humans who worked as dial painters, based on the results of whole-body $\gamma$ counting, analysis of breath for Rn content, analysis of tissues obtained at autopsy, and radiometric analysis of samples of blood, feces, and urine for $^{226}$Ra content. Whole-body $^{226}$Ra burdens were also determined for several humans who ingested $^{226}$Ra and $^{228}$Ra mixtures for medical reasons. Calculations of body weight were made for 10 human subjects based on results of whole-body counting after the administration of a tracer dose of $^{42}$K. Case history summaries are included for approximately 90 patients with body burdens of $^{226}$Ra and $^{228}$Ra. (C.H.)

**20403** CYTOGENETIC STUDIES ON BLOOD CELLS DURING X RAY THERAPY OF ECZEMAS. Heitmann, H. J. (Univ., Munich). Hautarzt, 19: 31-3(Jan. 1968). (In German).

Chromosomal changes in leukocytes taken from five patients treated with dermopan x irradiation for lichenified eczema of the hands, lower arm, and feet were studied. When the chromosomes were irradiated prior to longitudinal division, an acentric chromosome with a total number of 47 was observed in the metaphase plate. Similar effects were observed after both chromatids were irradiated after longitudinal division. It was considered possible that the appearance of a chromatid gap and chromatid break resulted from irradiation of a chromatid after longitudinal division. It was believed that the acentric chromosome fragments would not be arranged with the daughter nuclei, but would remain in the cell protoplasm because they had lost association with the kinetic apparatus. A fraction of the soft x irradiation which had reached the lymphocytes in the subepidermal blood vessels of the skin probably caused the chromosome aberrations observed. However, most of the effects may have resulted indirectly from intermediate products produced by the irradiation. (BBB)

**20404** SEX RATIO OF CHILDREN BORN TO MOTHERS WHO HAD BEEN EXPOSED TO X RAYS IN UTERO. Meyer, Mary B.; Diamond, Earl L.; Merz, Timothy (Johns Hopkins Univ. School of Hygiene and Public Health, Baltimore). Johns Hopkins Med. J., 123: 123-7(Sept. 1968).

To determine the effect of diagnostic x-ray exposures on developing oocytes, an epidemiological study of reproducing capacity is being conducted in human females exposed to x rays during fetal life, and of a matched population of unexposed controls. Two generations of births ($F_1$ and $F_2$) are being studied. The $F_1$ generation comprises the babies who were exposed to x-rays in utero and their matched controls. The $F_2$ generation comprises the babies born to these mothers. They arose from oocytes which, in the exposed group, received varying amounts of ionizing radiation from x rays at varying stages during fetal life. Births to mothers whose oocytes were exposed to x rays during their fetal life and births to unexposed matched controls showed no significant differences when the 2 groups were compared as a whole. However, analysis by time of exposure showed a pre-

ponderance of males and a dearth of females among offspring arising from oocytes exposed before 30 weeks of fetal life. An excess number of males accompanied by a deficiency of females suggests an excess prenatal loss of female products of conception. This might occur as a result of nondisjunction in the oocyte because of the greater viability of XXY males than of XO females. (BBB)

**20405** EXPERIMENTAL INDUCTION OF OSTEOSARCOMAS. Finkel, Miriam P.; Biskis, B. O. (Argonne National Lab., Ill.). Progr. Exp. Tumor Res., 10: 72-111(1968).

This review considers the oncogenic response to bone-seeking radionuclides under standard conditions. The dose-response relations, latent period, histopathology, and anatomic location for $^{226}Ra$, $^{239}Pu$, $^{232}U$, $^{233}U$, $^{90}Sr$, and $^{45}Ca$ are described. The susceptibility of different strains of mice, and comparative effects of continuous and limited exposures are other major topics considered. In general, $\alpha$-emitting isotopes are more oncogenic than $\beta$ emitters, isotopes with strong $\beta$ rays are more oncogenic than those with weak $\beta$ rays, and very short-lived materials are relatively poor oncogenic agents. In most experiments, $^{226}Ra$ has been the standard for comparing the oncogenicity of various radionuclides. Radium also is the common denominator for extrapolating experimental data to estimation of the human hazard, a procedure made possible by the invaluable information from clinical Ra cases. Tumor site depends upon microscopic location of the radionuclide and upon the effective range of its radiation; tumor incidence depends upon the magnitude of the dose as well as upon its temporal and spatial distribution. In general, osteosarcomas arising spontaneously and those induced by most radionuclides are indistinguishable, radiographically, and histologically. In the authors' experience, every animal that received an adequate amount of a bone-seeking radionuclide under suitable conditions eventually died with a malignant bone tumor. Every osteosarcoma processed in search of virus (mouse, dog, or human) contained electron-dense particles (visible with negative-staining). It is speculated that latent virus always is present and that the role of radiation in the oncogenic process is to inactivate a constituent of the cell that normally inhibits viral replication. (BBB)

**20406** RELATION BETWEEN DOSE AND VARIOUS LATE X-RAY SYMPTOMS OF THE SKIN. Klostermann, G. F. (Univ., Goettingen, Ger.). Z. Haut- Geschlechtskr., 41: 132-40(Aug. 15, 1966). (In German).

Skin injuries found in 185 patients who had been treated for hemangiomas 6 to 13 yr previously with x irradiation, at a 1.5-cm focus-skin distance, are reported. Total doses ranged from 500 to 3000 R, with doses of 400 to 500 R given at 4- to 8-week intervals. The radioinduced skin changes found included depigmentation, telangiectasis, hyperpigmentation, and epidermal atrophy. Depigmentation was found least frequently, and appeared after doses of 500 to 1000 R. Higher doses did not increase the frequency of depigmentation above 20%. Telangiectasis frequency was 51.5% of total and was 29% more frequent than depigmentation in the 500 to 1000 R dose range. The maximal frequency was found after doses of 1000 to 1500 R. Epidermal atrophy frequency peaked in the same dose range as telangiectasis, and appeared relatively infrequently at higher doses. Vitiliginous pigmentation was found frequently after doses of 1500 to 2000 R. With the exception of depigmentation, the appearance of which was constant in all the other x-irradiation symptoms increased at doses over 1000 R. The greatest increase in these was between 1000 and 1500 R. Telangiectasis frequency was 31%, pigmentation frequency was 61%, and epidermal atrophy frequency was much greater than these. (BBB)

**20407** CONSTRICTIVE PERICARDITIS FOLLOWING IRRADIATION THERAPY. Macleod, Cathel A.; Schwartz, Harold; Linton, Donald B. (Veteran's Administration Hospital, Cleveland. Western Reserve Univ., Cleveland). J. Amer. Med. Ass., 207: 2281-2(Mar. 24, 1969).

Constrictive pericarditis was found in a patient receiving mediastinal irradiation for metastatic seminoma. The gradual onset of symptoms following irradiation, together with the absence of features commonly associated with the more common causes of constrictive pericarditis, are highly suggestive of a causal relationship. (auth)

**20408** RECENT CONCEPTS OF CANCER PREVENTION. Raven, R. W. (Royal Cancer Hospital, London). Progr. Exp. Tumor Res., 10: 133-62(1968).

Carcinogenic agents, including ionizing radiation, and prevention of their effects in humans are reviewed. There is substantial experimental and clinical evidence of the cancer hazard from ionizing radiation in humans, the radiation being from various sources, including cosmic rays, radioactive elements in the earth's crust, and body radioisotopes. Some factors which modify human exposure to natural radiation are given. Radiation-induced breast cancer is considered in particular. Among 50 cases of breast carcinoma that had been treated for phthisis in a sanatorium, 40 had received treatment requiring repeated fluoroscopic chest examinations over long periods of time, so that the anterior chest wall, including the breasts, had received considerable doses of unfiltered x irradiation. The average latent period between radiation exposure and the clinical appearance of the carcinoma was about 16 yr. The number of radiological examinations of the chest should be limited, especially in young and middle-aged persons. The relation of radiation and cancer prevention is summarized. The size of the radiation dose which causes cancerous changes in human tissues is still unknown. It is not yet possible to speak of a safe level of radiation, so that it is advisable to reduce to a minimum amount all radiation received by humans. Thus, diagnostic radiological examinations should be made only when a precise need is indicated and multiple examinations should be avoided as far as possible. Radiotherapy is to be avoided for noncancerous and trivial lesions. A radiological protection service must be organized wherever humans are exposed to radiation occupational hazards. (BBB)

**20409** OSTEORADIONECROSIS OF THE ILIUM WITH SPONTANEOUS SEPARATION OF THE PELVIC RING. Fries, Giselbert (Univ., Homburg, Ger.). Arch. Orthopaed. Unfallchir., 61: 333-43(1967). (In German).

Usually radionecrotic damages after treatment of female genital carcinoma with x ray and radium radiation are seen on the upper end of the femur. However in three patients we found very large-spread necrotic damages in the area above the hip joint with spontaneous dissection of the pelvic ring. Two patients recovered with anatomically and functionally normal hip joint. In the third case it came to a complete resorption of the joint; possibly an extensive thrombosis of the pelvic and leg veins during the radiation has caused this result. In spite of the rareness of this form of radionecrotic damages we have to pay attention if patients complain about coxalgia after radiation of female genital carcinoma. Therapeutically the most important measure is to prevent spontaneous dissection of the pelvic ring and impression of the femoral head. The first principle is to avoid body weight bearing; later on we allow the use of crutches and a certain degree of weight bearing. According to our experiences spontaneous regeneration of bone structure and stability of the pelvic ring can be expected. (auth)

**20410** RADIATION HEMATOLOGY IN THE PAST AND PRESENT. Bauer, Robert. Strahlentherapie, 136: 387-94 (Oct. 1968). (In German).

A very brief review is given of the principal advances made in the knowledge of radiation hematology from the first of the century to the present. Among the developments mentioned are the effect of fractionated dose, the hematological picture of radiation sickness, hematological reactions in more or less local form, radiation leukopenia, and chronic professional radiation burden. (J.S.R.)

**20411** RADIODERMATITIS OF THE HANDS AND SURGICAL TREATMENT. Simon, G. C. Arch. Mal. Prof. Med. Trav. Secur. Sociale, 28: 792-5(Oct.-Nov. 1967). (In French).

Ionising radiation, especially X radiation, harms the skin, and surgeons were affected since they operated with their hands under a fluorescent screen. Lesions formed slowly, with no warning pain, in five, 10 or 15 years, and even without further radiation, developed towards cancer of the affected tissue. In view of this hazard, the hands should be protected and not exposed to direct radiation. The only valid treatment, if practiced in time, was excision and grafting. (CIS)

**20412** STUDIES ON RADIATION CYSTITIS IN GYNECOLOGICAL CANCER. Nishiyama, Takeshi (Osaka City Univ.). Osaka Shiritsu Daigaku Igaku Zasshi, 17: 325-44(Aug. 1968). (In Japanese).

Following radiation therapy, the urinary bladder was studied with urinalysis, on subjective symptoms and from cystoscopic examinations in 253 cases of 243 patients with gynecological cancer (cancer of the uterine cervix, corpus and ovary) who were examined in the department of gynecology from January 1963 to November 1967. The results obtained were as follows: (1) Fifty-two cases (20.6%) had subjective symptoms. Subjective symptoms were less in a preoperative group (10.9%) than in a postoperative group (26.1%). (2) In regard to bacteriuria, gram negative organisms were found in 131 (71.2%) of the 184 strains isolated. (3) Red blood cells, white blood cells and vesical epithelial cells in the urine increased as radiation treatment progressed but such finding was not characteristic. (4) The vesical membrane was edematous, erythematous and congestive. An experimental study of radiation cystitis in rabbits was made. About 100 female rabbits received the following X-ray irradiation over the bladder

region from 1 day to 5 weeks. (dosage: 1000R, 3000R or 5000R, 200kVp, 20mA, H. V. L. 1.07 mmCu, F. S. D. 30cm.) These rabbits were divided into 3 groups as to (a) fractional irradiation, (b) single irradiation and (c) single irradiation after hysterectomy. They were sacrificed at varying intervals after irradiation (the next day, 1 week later, 3 weeks later and 5 weeks later). The results obtained were as follows: (1) A fractional irradiation group was represented by fibrosis and telangiectasis in the bladder. (2) A single irradiation group was represented by a decreased size of epithelial cell and marked edema of the submucosa during the first three weeks followed by a recovery of the epithelial cells and a development of fibrosis. (3) A single irradiation after hysterectomy group was featured by initial edema of the submucosa and congestion followed by submucous fibrosis. (4) In each group, muscle fibers began to change their stainability 3 weeks after irradiation. (5) Reticulosis of lymphatic tissue was observed. (6) Bladder injury following radiation such as epithelial shedding, submucosal hemorrhage, perivascular lymphocytic infiltration and degeneration of muscle fibers was severe in the single exposure after hysterectomy group, while the fractional irradiation group showed little X-ray damage. (NSA of Japan)

**20413** EFFECTS OF MITOMYCIN C AND X-IRRADIATION ON COLONY-FORMING ABILITY OF MAMMALIAN CELLS GROWN IN VITRO. Hamada, Tatsumi; Yamazaki, Takeshi (Osaka Univ.). Nippon Igaku Hoshasen Gakkai Zasshi, 28: 1015-19(Oct. 1968).

A subline of HeLa cells growing in vitro was exposed to mitomycin C and the surviving fraction of cells was measured by their ability to form macroscopically visible colonies. Survival thus obtained yielded sigmoidal curves when plotted against the concentration of the drug as well as the duration of its contact with cells. Combination experiments of the drug and x rays failed to show synergism between the two agents. (NSA of Japan)

**20414** ASPECTS OF THE PROBLEM OF DIAGNOSTIC IRRADIATION. Weill, F.; Bonneville, J.-F.; Ricatte, J.-P. Presse Med., 76: 1666-8(Sept. 21, 1968). (In French).

Hazards doses of radiation used for diagnosis, particularly in obstetric practice, and means of lessening them are reviewed. Doses received in various diagnostic procedures are tabulated and compared with exposures from natural sources. The danger to the body of small doses of ionizing radiation is still not clear. The dose received during diagnostic procedures is usually considered negligible provided the gonads are protected. This is true only if the dose is small. Measurements at the skin level have shown that with improved technique it is possible to reduce greatly the radiation dose received even during high-risk examinations. There is little risk from fetal irradiation during routine radiography of pregnant mothers. However, all examinations which require fluoroscopy still carry a high risk. This can be minimized by the use of television, but its widespread use, originally intended only for examination of the gut, should be avoided. (BBB)

**20415** IRRADIATION AND THE FETUS. Weisberg, Martin G. (Mayo Graduate School of Medicine, Rochester, Minn.). Minnesota Med., 50: 1235-40(Aug. 1967).

Use of diagnostic radiation procedures in obstetrics and their hazards to the fetus are reviewed. Doses received in various procedures are given. The considerable variation between some of these doses for the same examination depends primarily on the particular x-ray technique and routine used by each investigator. Radiation exposure during pregnancy always involves both genetic and somatic effects by virtue of simultaneous exposure of both maternal and fetal gonads; partial somatic maternal exposure; and partial- or total-body irradiation of the fetus. The amounts of maternal gonadal, fetal gonadal, and fetal thyroid irradiation received from radioisotope placentography are described and compared with doses received from conventional, soft tissue x-ray placentography. Effects of radiation on embryogenesis are briefly reviewed, as are the medicolegal aspects of prenatal irradiation. Some standards and recommendations that have been proposed relative to radiation protection of the population in general and more specifically in the management of the obstetric patient are outlined. It is recommended that, whenever possible, x-ray examinations of the abdomen or pelvic areas in women of child-bearing age should be performed only during the first 10 days after a regular menstrual period. (BBB)

**20416** IRRADIATION THERAPY UNDER HYPERBARIC CONDITIONS. Saunders, William H.; Schloss, Charles D. (Ohio State Univ., Columbus). Ann. Otol., Rhinol., Laryngol., 77: 477-92(June 1968).

The radiosensitizing action of oxygen is discussed, as providing the rationale for hyperbaric radiotherapy. The clinical effects and complications of such therapy in 61 cases of head and neck cancer are presented. (BBB)

**20417** PROGRESS AND PROGNOSIS OF OCCUPATIONAL HEMATOLOGICAL RADIATION INJURIES. David, Alois (Karlovy Univ., Prague). Int. Arch. Gewerbepathol. Gewerbehyg., 24: 271-86(1968). (In German).

Changes in leukocyte counts in 50 out of 992 persons occupationally exposed to radiation were studied. With the exception of one case where a leukocytosis developed, the leukopenias studied consisted of cases where the blood picture varied between normal and leukopenic values. No morphological changes were observed in the leukocytes, erythrocytes, or thrombocytes. Most of the blood picture changes appeared abruptly after an average of 9.8 yr work with ionizing radiations. Most of the leukopenias improved when working conditions were improved, ~⅓ remained unchanged, but none worsened. Sternal marrow puncture counts varied slightly. Out of 13 persons whose bone marrow function was studied by the response to bacterial pyrogens the neutrophil increase was below normal in only two. Leukocyte mobility, osmotic resistance, cytochemical reactions for polysaccharides, lipids, RNA, peroxidase, and alkaline phosphatase, and average number of nucleoles of the lymphocytes were normal. None of the leukopenias indicated panmyelopathy. References cited, 70. (BBB)

**20418** THE FREQUENCY OF DELAYED HYPOTHYROIDISM AFTER TREATMENT OF HYPERTHYROIDISM BY RADIOIODINE-131. RESULTS OF A SURVEY OF 96 PATIENTS WITH A 5 TO 12 YEAR HISTORY. Berger, M.; Briene, J. (Faculte de Medecine et Pharmacie, Lyon). Presse Med., 76: 607-10(Mar. 16, 1968). (In French).

The incidence of hypothyroidism in 96 patients treated with $^{131}I$ six to seven yr previously was 30.2%. In 11.4% of the patients, symptoms indicated incipient hypothyroidism. Of the cases of post-therapeutic hypothyroidism, 62% were untreated. According to experience, the most efficacious, and also safest therapeutic dose was between 8,000 and 10,000 RAD. Great caution in administering $^{131}I$ to young patients and in using repeated doses was recommended. It was recommended that programs to detect development of post-treatment hypothyroidism should be instituted, and functional activity of the irradiated thyroid gland should be evaluated periodically by studies of protein-bound I. (BBB)

**20419** LASER RADAR EYE HAZARD CONSIDERATIONS. Wyman, P. W. (Naval Research Lab., Washington, D. C.). Appl. Opt., 8: 383-92(Feb. 1969).

An analysis is made of the eye hazard posed by laser radars and the methods for reducing this hazard. The particular situation analyzed is that of a person at target range being exposed to a single pulse by accidentally looking directly into a laser beam. Curves are presented which show where the safe and hazardous radar regions occur. The curves show that by following a philosophy of transmitting no greater intensity than is necessary to achieve a given level of radar performance, the eye hazard can be considerably reduced. (auth)

## Radiation Effects on Plants

*Refer also to abstracts 19884, 20109, 20148, 20163, and 20337.*

**20420** (ORNL-TM-2466, pp 2-17) EFFECTS OF EXTERNAL BETA RADIATION ON HIGHER PLANTS. Witherspoon, John P.; Taylor, Fred G. Jr. (Oak Ridge National Lab., Tenn.).

Experiments were conducted to determine relative radiosensitivities and to establish types of biological effects produced by external beta radiation. A fallout simulant consisting of albite particles containing $^{90}Sr$ was prepared. Plant surfaces were painted with the particles coated with glycerol; controls were painted with glycerol without the fallout simulant. Experiments on Pinus strobus, Xanthiam pensylvanicum, and Phaseolus vulgaris were conducted in environmental growth chambers. The tabulated results show that plant parts that received contact exposures were killed while other plant organs survived with varying degrees of biological damage depending on distance from the contaminated area of the plant. Other experiments designed to assess the hazard of beta-field radiation geometries were conducted. Cylindrical sources were placed over selected plant parts and removed at intervals so that total dose to plant parts could be controlled. White pine, a radiosensitive species, and red oak, a relatively radioresistant species, were used. Beta doses above 338 rads (12 hr exposures) to pines prevented growth of shoot buds exposed inside the cylinders. In red oak trees doses exceeding 1500 rads (delivered in 1 to 3 days) were sufficient to kill apical buds. Growth of shoots was severely impaired at doses in the range of 500 to 750 rads. (H.L.W.)

**20421** THE EFFECTS OF THALIDOMIDE ON THE EMBRYONAL DEVELOPMENT OF ARABIDOPSIS THALIANA. Arnold, Carl Gerold; Cruse, Dorio (Univ., Erlangen, Ger.). Z. Pflanzenphysiol., 56: 292-4(1967). (In German).

The effects of sublethal x irradiation on embryonal development of Arabidopsis thaliana were compared with those of thalidomide. At doses of 2500 R or less the development of the embryo remained uninhibited until the globular stage was reached. At that stage, differentiation to the heart-shaped embryonic stage which leads to formation of the cotyledon was prevented in some samples, but in the rest development was normal. The transition from the globular stage to the heart-shaped stage represented a critical phase of embryonal development. It was not possible to ascertain whether the effects of irradiation or thalidomide on embryonal development of A. thaliana were due to metabolic or physiological disturbances or to mutational changes. (BBB)

**20422** RADIOSENSITIVITY AND RATE OF CELL DIVISION: "LAW OF BERGONIE AND TRIBONDEAU." Haber, Alan H.; Rothstein, Barbara E. (Oak Ridge National Lab., Tenn.). Science, 163: 1338-9(Mar. 21, 1969).

The rate of cell division decreases as tobacco leaves grow, and older leaves grow without any cell divisions. Disks were cut from leaves having differing degrees of cell division at various developmental stages. In the chlorenchyma, the induced susceptibility to photodestruction of chloroplasts was used to measure sensitivity to $\gamma$ radiation as a function of the rate of cell division. The same biological effect can thereby be studied both in dividing and in nondividing tissues of the same morphological and physiological cell types. The radiosensitivities were approximately the same, irrespective of the extent of cell divisions. (auth)

**20423** PRESOWING IRRADIATION OF CORN SEEDS INCREASES YIELD AND QUALITY. Mukhanova, V. L.; Khaidarov, E. (All-Union Scientific Research Inst. of Cotton Economy, Tashkent). Kukuruza, 4: 8-9(1967). (In Russian).

Dry hybrid corn seeds received presowing treatment with $^{60}$Co $\gamma$-ray doses of 500, 1000, and 3000 R. Exposure of corn seeds to 500 R doses induced no stimulation, but 1000 and 3000 R total doses at 780 R/min effected a vigorous growth and yield increase. The total doses of 3000 R increased the yield by 12.7% to 62.1 centner/hectare, and the total doses of 1000 R stimulated the yield by 14.7% to 71.1 centner/hectare, but in both cases the quality of the product was slightly inferior. Repeat experiments a year later were intended to correct certain shortcomings. The total $\gamma$ radiation doses used were 500, 1000, 2000, and 3000 R at 1320 R/min, but were applied on the day of corn sowing and were repeated four times. Results after plantings showed vigorous field germination, dense growth, and upright standing plants with a fuller and qualitatively better yield of corn ears, and an increased viability of the stem and foliage of plants. Two doses of $\gamma$ irradiation of 1000 and 2000 R at 1320 R/min on the day of sowing were credited with the results obtained. The starch content in grains of corn was doubled. (BBB)

**20424** PREPLANTING TREATMENT OF POTATO TUBERS WITH $^{60}$Co $\gamma$ RAYS AND ITS EFFECT ON POTATO YIELD. Serebrennikov, V. S.; Kiryukhin, V. P. Dokl. Vses. Akad. Sel'skokhoz. Nauk, No. 10, 7-11(Oct. 1965). (In Russian).

In experiments with a preplanting irradiation schedule extended to 30 days, potato tubers were irradiated for 3 seasons by a $^{60}$Co $\gamma$-ray source with total doses equivalent to 100, 300, and 1000 R of x rays at 317 R/min. The best results were obtained with a 6- to 10-day schedule of preplanting irradiation with total $\gamma$ radiation doses ranging in equivalents from 150 to 500 R. Eyes and buds of potato tubers not only appeared abundantly, but also 3 to 4 days sooner than those in the nonirradiated series. Growing sprouts showed increased physiological activity resulting from the stimulated fermentative action on starch which was readily converted into soluble carbohydrates. Generally, the extension of preplanting irradiation past the 6- to 10-day schedule induced premature sprouting and consequent breaking of weak shoots in the field, whereas the increase of total radiation doses above the 500-R range delayed physiological activity by 3 to 4 days, and also reduced the crop rate per plant. The average yield of two varieties of potatoes, regular and early ripening, for three seasons under the optimum conditions in bog peat soil was: 228.1 centner/hectare (control 135.0) and 186.4 centner/hectare (control 124) respectively; in sandy soil: 235.8 centner/hectare (control 120) and 187.3 centner/hectare (control 128). (BBB)

**20425** EFFECTS OF GAMMA IRRADIATION ON PRICKLY PEAR CACTUS. Monk, Carl D. (Univ. of Georgia, Athens). Quart. J., Fla. Acad. Sci., 30: 168-72(Sept. 1967).

A 12-yr-old field on the AEC Savannah River Plant was exposed for 400 hr to a 9200-Ci $^{137}$Cs irradiator. Scattered through the exposed portion of the community were 45 plants of prickly pear cactus (Opuntia compressa). The radiation exposure of each plant was monitored, and the plants were arranged in descending order of radiation exposure, 31.3 to 0.1 R/hr. All flower and vegetative buds aborted on plants receiving in excess of 22.5 R/hr. Plants with exposures greater than 27.5 R/hr died within a month following irradiation. Subsequently, all plants died when exposed at a rate of 18.7 R/hr, or higher. Fruit size, seed weight, and seeds/fruit were more radiation sensitive than fruit and stem segment survival. The former three exhibited a marked reduction between 2.9 and 5.9 R/hr. Fruit survival began to decrease at the same radiation level. Stem segment survival was not materially affected until the 23.5 R/hr isodose line. One year following irradiation, the prickly pear cactus population still exhibited a response to exposure. All plants with less than 17.5 R/hr produced flower buds, but at a consistently lower level than in 1965. Plants exposed to 9.3 R/hr or more were less productive than the rest of the population. No fruits survived on plants receiving in excess of 13.6 R/hr, and seed weight tended to be lower at the higher exposures. An enhancement of vegetative bud production at the 13.0 to 5.9 R/hr levels was seen, and interpreted as a stimulatory effect. (BBB)

**20426** USE OF IONIZING RADIATIONS FOR IMPROVEMENT OF MEDICINAL AND AROMATIC PLANTS. Kapoor, M. L.; Datta, S. C. (Central Indian Medicinal Plants Organizations, Lucknow, India). Perfum. Essent. Oil Rec., 58: 442-4(July 1967).

Rooting tillers from Cymbopogon nardus, Eucalyptus citriodora seeds, and healthy suckers of Mentha arvensis were irradiated with doses of up to 25 KR from a $^{60}$Co source over periods of time up to 250 hr. Survival of the C. nardus decreased as the dose rate increased. Increased tillering was observed at all doses. Mean plant height and length increased after irradiation. Of the third leaf generally decreased after irradiation, high tillering was observed in one variant. In M. arvensis germination decreased from 80 to 30% after irradiation up to 3 KR and suckers irradiated to 4 KR did not germinate. Irradiated E. citriodora seeds did not survive after germination. The optimum dose for induction of economically important mutants of C. nardus was 5 KR. (BBB)

**20427** THE EFFECT OF LOW GAMMA-RAY DOSES $^{60}$Co ON BEAN AND SOYBEAN PLANTS. Stan, S.; Jinga, A. An. Inst. Cercet. Pentru Cereale Plante Teh. Fundulea, 34: 369-76(1966). (In Rumanian).

The effect of low $\gamma$-ray doses of $^{60}$Co on seed germination, flowering and production of kidney beans and soybean plants obtained from irradiated seeds was studied. Dry seeds were exposed to doses of 25, 100, 500, 1000, and 2000 R and sown in pots in a mixture of soil and sand. Seed irradiation induced important changes. An important stimulation of seed germination during the first 5 days, with doses up to 500 R, was noted in both species. However, bean plants obtained from seeds irradiated at all the doses surpassed controls during the whole germination period while in soybeans, the control equalled the plants exposed to low radiation doses and surpassed the ones exposed to high doses. Bean plant flowering was slightly stimulated by doses up to 500 R, while with high doses ranging between 500 to 2000 R, flowering was retarded. Soybean plants obtained from seeds exposed to low radiation doses exhibited no obvious effect on flowering. Retardation of flowering occurred with radiation doses of 500 to 2000 R. Yield increases were noted for both species with doses ranging between 25 and 500 R; 100 R was the optimal radiation dose in seeds. Yield increases ranged between 3 and 14 per cent for bean plants and 2 to 5 per cent for soybeans. Changes in the seed/pod ratio were noted in all the cases. Yields increased by low seed exposures are discussed. (Rom. Sci. Abstr.) (TSS)

**20428** GERMINATION AND GROWTH OF THE ORCHID SEEDS IRRADIATED BY GAMMA RAYS. Miyazaki, Sadami (Saga Univ., Japan). Saga Daigaku Nogaku Iho, No. 25, 101-12 (Mar. 1968). (In Japanese).

Dendrobium nobile seeds were exposed to doses of 10, 20, 30, 40, 60, and 80 kR of $\gamma$ rays from $^{137}$Cs (experiment I) or $^{60}$Co (experiment II). Seeds were sown on artificial modified Knudson C culture medium. The germination of seeds (formation of protocorm), and the further growth and development of germinated seeds were inhibited by radiation. Various deformations were found especially at higher dosages. Germination and development were followed for 12 weeks. The radiosensitivity of orchid seeds was indicated on the basis of germination rate, survival rate, relative survival rate, and deformation rate. Differences in germination rate were found 3 weeks after sowing not only between irradiated seeds and non-irradiated ones, but also among seeds

irradiated at different dosages. The germination rate of irradiated seeds were lower than that of control seeds and declined with the increase of dosage, but the rate in each plot reached almost constant value about 6 weeks after sowing. Concerning the survival rate, differences were found in the same tendency as that of germination rate. But in the plot with 40 kR irradiation reduced the survival rate abruptly and the growth stopped at the highest doses. The relative survival rate with 50% was found in the plot with 20 kR irradiation in experiment I (dose rate: 394 R per min.), and in the site between 30 and 40 kR irradiated plot in experiment II (dose rate: 5.21 to 6.94 R per min.). Many deformed plants were found in irradiated plots, few in controls. As the doses increased, deformation rates increased. In the plot with 40 kR irradiation, about 70% of the plants that survived 12 weeks after sowing showed deformity. (NSA of Japan) (TSS)

**20429** INFLUENCE OF γ-RAY RADIATION ON THE GERMINATION OF EPHEDRA ALTISSIMA DESF. AND BUPLEURUM FALCATUM L. Fujita, Sanaenosuke; Kawatani, Toyohiko (National Inst. of Hygienic Science, Tokyo). Eisei Shinkenjo Hokoku, No. 85, 110-12(Dec. 1967). (In Japanese).

The effect of γ radiation on the germination of Ephedra altissima Desf. and Bupleurum falcatum L. was studied, by irradiating the air-dried seeds. The doses were O(control), 500 R, 1,500 R, 4,500 R, 13,500 R, 40,500 R, and 121,500 R. In E. altissima, there was no significant difference in germination at doses up to 40,500 R, but no germination was observed at the dose 121,500 R. In B. falcatum, there was no significant difference in germination at doses up to 4,500 R; germination at doses greater than 13,500 R decreased suddenly, and at doses of 40,500 R to 121,500 R there was almost no germination. (NSA of Japan) (TSS)

**20430** DESTRUCTIVE EFFECT OF VAPOUR HEATING AND γ-RAY RADIATION ON THE GERMINATION OF PAPAVER SOMNIFERUM L. AND CANNABIS SATIVA L. 1. Fujita, Sanaenosuke; Kawatani, Toyohiko (National Inst. of Hygienic Science, Tokyo). Eisei Shinkenjo Hokoku, No. 85, 68-71(Dec. 1967). (In Japanese).

The effect of vapor heating and γ radiation on the germination of the two plants was studied in two strains each, domestic and foreign. In the case of P. somniferum, in general (strain as random model): the effect of vapor heating destroyed germination almost completely at vapor pressures of 3 pound 2 min, 1 pound 3 min, and 2 pound 2 min; the effect of γ radiation destroyed germination at doses more than 80,000 R; and the interaction of strain × treatment was highly significant. In the case of C. sativa, in general: the effect of vapor heating destroyed germination almost completely at vapor pressures of 1 pound 3 min and 3 pound 2 min; the effect of γ radiation was not significant; and the interaction strain × γ radiation was highly significant. In the Japanese strain, at the dose 640,000 R, germination began to decrease, and finally at the dose 2,560,000 R germinating power was lost. It seems that C. sativa is more resistant to the γ radiation than P. somniferum. (NSA of Japan) (TSS)

**20431** SYNTHESIS OF ATP AND RECOVERY FROM DAMAGE BY ULTRAVIOLET OR γ-IRRADIATION IN YEAST. Mosin, A. F. (Inst. of Medical Radiology, Obinsk, USSR). Nature (London), 221: 261-3(Jan. 18, 1969).

Recent studies suggested that dark reactivation in organisms other than yeast, and particularly in UV irradiated bacteria in nutrient media, was based on enzymatic repair of potentially lethal structural defects in DNA. The stages of this repair were strongly energy dependent repair-replication processes. It was not known whether the same mechanisms operated in yeast incubated in water after UV or γ irradiation; if these mechanisms operated, recovery of the cells should be sensitive to inhibition of ATP synthesis. Studies were described indicating that recovery from γ injury was not influenced by treatment of yeast with phosphorylation inhibitors, whereas dark reactivation in yeast exposed to UV radiation was greatly inhibited by such treatment. Cells of diploid yeast, Saccharomyces vini, strain Megry 139 B, were used in the studies. The greatest inhibition was observed under anaerobic conditions. The effect of As or DNP as phosphorylation inhibitors on recovery in yeast incubated aerobically or anaerobically was shown graphically. As in γ-irradiated yeast, recovery in cells exposed to UV radiation in anaerobic conditions proceeded to a large extent only in the presence of exogenous carbohydrates. Results using As as inhibitor appeared to indicate that dark repair in yeast exposed to UV was closely dependent on the rate of ATP synthesis and on the ATP content in the cells. Recovery in γ-irradiated yeast incubated anaerobically was not influenced by As treatment, leading to the assumption that the energy requirement for recovery from γ damage was very small. Results indicated that cell oxidation processes were important for recovery irrespective of their participation in ATP synthesis; also that the rate of inhibition of phosphorylation with DNP in the presence of oxygen was not large. (UK)

**20432** PHYSIOLOGICAL AND CYTOGENETICAL ASPECTS OF THE EFFECT OF SODIUM AZIDE ON IRRADIATED AND NON-IRRADIATED BARLEY SEEDS. Sideris, Eleftherios George. Pullman, Wash., Washington State Univ., 1968. 99p. Thesis.

The influence of sodium azide, an inhibitor of catalase, peroxidase, cytochrome oxidase, and of certain steps of oxidative phosphorylation on the extent of biological damage, induced by ionizing radiation was tested as measured by seedling growth and chromosome aberrations. In preliminary experiments, without irradiation, seeds (caryopses) of Hordeum vulgare var. Himalaya were hydrated in $10^{-2}$, $10^{-3}$, and $10^{-4}$ M sodium azide solutions buffered at pH 3, 7, and 11 by 0.1 M phosphate buffers. It was found that seedling growth was strongly reduced only when the sodium azide solutions were buffered at pH 3. Buffer concentration within the range 0.125 to 0.5 M did not alter the observed relationship between pH of the hydrating solution and injury. The influence of pH on the effectiveness of sodium azide treatments to barley seeds appeared to be independent of the chemical constitution of the buffering systems, since similar results were obtained when 0.1 M sodium biphthalate, tris(hydroxymethyl)aminomethane and sodium bicarbonate buffer solutions were substituted for phosphate buffer solutions. When barley seeds were hydrated for four hours at 20 C, in $10^{-2}$, $10^{-3}$, and $10^{-4}$ sodium azide solutions buffered at pH 7 by 0.1 M phosphate buffer and then transferred for 2 hr into 0.1 M phosphate buffer solutions at pH 3, 7, and 11, the observed injury was greatest at pH 3. To study the effect of azide posttreatment on radioinduced biological damage seeds of 9.5 and 14.0% water content sealed in glass vials under nitrogen atmosphere were first irradiated with 2, 4, 8, and 16 krad of γ rays from a Cobalt-60 source. After irradiation the seeds were hydrated at 20 C for four hours in nitrogen or oxygen bubbled sodium azide solutions buffered at pH 3, 7, and 11. Then the seeds were washed and planted in blotters. The seedling height at the sixth day after planting as well as the chromosome aberrations in the first mitotic division in the emerging shoot-tips were used as criteria of the sodium azide-ionizing radiation induced injury. Results with both biological criteria indicated that the hydration of irradiated barley seeds in sodium azide solutions buffered at pH 3 resulted in an increase of the damage induced by ionizing radiation. The synergism between the effect of radiation and that of sodium azide was best expressed by seeds irradiated with 16 krad and hydrated in $10^{-4}$ M sodium azide solutions. The catalase and peroxidase activity as well as the respiration of barley seeds, which had been hydrated for four hours at 20 C in sodium azide solution buffered at pH 3, 7, and 11 by 0.1 M phosphate buffers was measured. Catalase activity measured by oxygen evolution was strongly decreased only in seeds hydrated in sodium azide solutions buffered at pH 3. Similar results were obtained for peroxidase activity measured by the p-phenylenediamine colorimetric technique. Respiration measured by oxygen absorption was also inhibited in seeds hydrated in sodium azide solutions buffered at pH 3. At pH 11 there appeared to be no inhibition of enzymatic activity and no apparent synergism between the effect of sodium azide and that of ionizing radiation on biological damage. The results indicated that at pH 3 a strong synergistic effect between sodium azide and ionizing radiation induced damage was associated with a strong inhibition of catalase, peroxidase, and respiratory activity induced by sodium azide. (Disser. Abstr.)

**20433** EXPERIMENTS WITH WHITE RATS, BUSH BEANS, AND TRADESCANTIA PLANTS IN THE VICINITY OF TELEVISION RECEIVERS. Harvey, Thomas S. (Bio-Analytical Lab., Freehold, N. J.). IEEE (Inst. Elec. Electron. Eng.) Trans. Broadcast Telev. Receivers, 13: 51-63(July 1967).

Weanling rats located within 10 in. of a color television set, and which accumulated about 240 times the average dosage of a television viewer watching for 1000 hr at a distance of 40 inches, developed normally and produced normal offspring, including the second generation of rats born in front of the receiver whose behavior and anatomy were normal. Examination of tissue samples of the brain, gonad, spleen, and sternum showed no abnormal morphology. Bush bean seedlings and Tradescantia cuttings grew to maturity and reproduced without abnormal morphology following the same exposure. There were two series of tests. The first series was made in front of 21-in. round color picture tubes operating normally with 25 KV on the screen. In the second set of tests four receivers with 25-in. rectangular color picture tubes, nonlaminated, were altered to produce amounts of radiation ranging up to 1.9 mR/hr. At the low level of ionizing radiation of 0.05 mR/hr from color television sets currently being manufactured, a child located only 40 in. from a 25-in. color set and watching

3 hr/day would accumulate in 1 yr a gonad dose of only 1.7 mR from the television set and ~100 mR from surroundings, such as the wall, floor, and air. At high altitudes, surroundings would contribute about 200 mR/yr. (BBB)

**20434** THE EFFECTS OF CHRONIC GAMMA RADIATION ON THE INTERNAL APICAL CONFIGURATIONS OF THE VEGETATIVE SHOOT APEX OF COLEUS BLUMEI. Crockett, Lawrence J. (City Coll., New York). Amer. J. Bot., 55: 265-8 (1968). (BNL-12282).

Clonal plants of a bushy variety "Trailing Queen" of Coleus blumei Benth. were exposed to 600 to 700 R per day for 28 days. Shoot apices of control and irradiated plants were studied microscopically. The normal vegetative shoot apex has two tunica layers and a corpus which is partly layered and partly composed of randomly divided cells. Five cytohistological zones were observed, including a cup-shaped zone, imposed upon the tunica-corpus relationships. Response to gamma radiation resulted in abnormal internal apical configurations. All irradiated shoots were found to have the same internal configurations. Only a single tunica layer broken by occasional periclinal divisions was observed. The cytohistological organization of irradiated apices was different from that seen in the normal shoot tips in that two zones were found. Evidence of a radiosensitivity gradient within the vegetative shoot apex was also observed. The possible significance of the results is discussed. (auth)

**20435** EVIDENCE FOR A TRIGGERED OR ACTIVATED RADIATION REPAIR SYSTEM IN SACCHAROMYCES CEREVISIAE. Calkins, John; Todd, Willis (Univ. of Kentucky, Lexington). Int. J. Radiat. Biol., 14: 487-91(Dec. 1968).

The survival curves were shown for the effects of uv irradiation on Saccharomyces cerevisiae and Tetrahymena pyriformis. With increasing dose the curve first fell, then rose, and at higher doses fell again. This was interpreted as uv reactivation and the triggered and activated radiation repair system was discussed. (F.M.M.)

**20436** RBE, OER, AND DOSE-RATE EFFECTS WITH 14 MeV NEUTRONS RELATIVE TO 300 kVp X-RAYS IN BARLEY ROOTS. Cercek, L.; Ebert, M.; Greene, D. (Christie Hospital and Holt Radium Inst., Manchester, Eng.). Int. J. Radiat. Biol., 14: 453-62(Dec. 1968).

The effects of 14 MeV neutrons, 300 kVp x rays, $^{60}$Co $\gamma$ rays and 10 MeV electrons on the growth of barley roots were investigated. The RBE values for 14 MeV neutrons versus 300 kVp x rays were: anoxic conditions: 6.01 ± 0.36, oxic conditions: 3.39 ± 0.23 at dose-rates of x rays higher than 48 rads min$^{-1}$, and 6.0 ± 0.04 at dose-rates of x rays from 17 to 5.5 rads min$^{-1}$. No dose-rate effects were observed for 14 MeV neutrons for the range from 8.5 rads min$^{-1}$ to 1.5 rads min$^{-1}$. The RBE of $^{60}$Co $\gamma$ radiation versus 300 kVp x rays was 0.79 ± 0.05 and 0.77 ± 0.24 in oxic and anoxic conditions, respectively. The oxygen enhancement ratio (OER) for x rays was 3.4 ± 0.4, and for 14 MeV neutrons 1.92 ± 0.76, i.e., a gain factor of 1.8 ± 0.2. (auth)

**20437** EFFECT OF IONIZING X-RAYS ON THE SHOOT APICAL ORGANIZATION OF SESAMUM INDICUM DC. Sarkar, S. S. (Bose Inst., Calcutta). Trans. Bose Res. Inst. (Calcutta), 30: 21-5(Mar. 1967).

Investigations were made on the effects of ionizing x rays at three different doses on the shoot apical organization of Sesamum indicum DC., strain T-16, in the light of the tunica-corpus concept. The study revealed that morphological abnormalities were related to anatomical changes in the tunica layers of the shoot apex. Necrosis, plasmolysis and vacuolation occurred at lower doses when the corpus layer cells remained unaffected. At higher doses complete killing of the inner layer of the biseriate tunica and vacuolation and necrosis in the corpus layer cells also took place. Morphological manifestations of radiation response at later stages (fourth node here) were accounted for as a delayed radiation effect. It was also shown that the meristem was more radiosensitive than other shoot apical cells. (auth)

**20438** THYMIDINE KINASE IN IRRADIATED WHEAT. Kern, Hartmut (Kernforschungsanlage, Juelich, Ger.). Z. Naturforsch., 24b: 240-2(Feb. 1969). (In German).

Biochemical analyses on wheat varieties of differing sensitivity to x radiation, were made. Ionizing radiation led to a dose-dependent germination delay, related to the reduction of nucleic acid and protein synthesis and to the inhibition and finally the recovery of mitotic activity. Dry irradiated karyopses allowed for the possibility of following the transition from the rest state in the first germination phases and therefore of detecting the relation between radiation cause and its effect. (tr-auth)

# Radiation Effects on Microorganisms

*Refer also to abstracts 20147, 20165, and 20337.*

**20439** (BNL-50058, pp 77-97) LETHAL SECTORING IN YEAST. James, Allen P. (Atomic Energy of Canada Ltd., Chalk River (Ontario). Chalk River Nuclear Labs.).

Several different mechanisms are offered as explanations of radioinduced lethal sectoring in polyploid Saccharomyces sp.; included were immediate genetic damage with delayed expression, delayed mutation because of the presence of an induced chemical mutagen, and cytoplasmic damage. Repair of the damage responsible for lethal sectoring was evident in the decrease in frequency of sectoring that accompanied a delay in postirradiation cell division. (C.O.)

**20440** THE EFFECTS OF DARK HOLDING AND PHOTOREACTIVATION ON ULTRAVIOLET LIGHT-INDUCED MITOTIC RECOMBINATION AND SURVIVAL IN YEAST. Parry, James M. (University Coll. of Swansea, Singleton Park, Wales); Cox, B. S. Genet. Res., 12: 187-98(Oct. 1968).

Treatment with photoreactivating light decreased uv-induced cell death and intragenic recombination but had no influence on intergenic recombination in Saccharomyces cerevisiae. Experiments on the effect of dark holding on survival, intragenic and intergenic recombination in uv-treated cultures of this organism are reported. The uv-treated cultures were also exposed to photoreactivating light before and after periods of dark holding so that the interaction of the 2 mechanisms of repair could be studied. It was found that dark holding reduced cell death and intergenic recombinants, but caused an increase in intragenic recombination frequency. Photoreactivation reduced cell death and intragenic recombination, but had no effect on intergenic recombination. After dark holding, photoreactivation had no further effect on cell survival or intergenic recombination, but may have reduced the frequency of intragenic recombinants. After photoreactivation, dark holding still caused an increase in cell survival and the frequency of intragenic recombination, and reduced the frequency of intergenic recombination. (BBB)

**20441** THE CHANGE OF SENSITIVITY TO UV IRRADIATION DUE TO INTERVENTIONS BEFORE AND AFTER IRRADIATION IN RESISTANT AND SENSITIVE STRAINS OF E. COLI. Slamenova, Darina; Sedliakova, Milena (Biological Inst., Bratislava). Biologia (Bratislava), 22: 648-53(1967).

The degree of lethality of uv irradiation by uv-sensitive and uv-resistant Escherichia coli B variants was studied, when prior to irradiation they were cultivated for various lengths of time in a medium without a source of energy, glucose. Simultaneously, the effect of starvation was combined with 40-min cultivation of irradiated cultures in a complete liquid medium. This effect was examined after various periods of starvation. It was found that both uv-resistant and uv-sensitive strains in the course of glucose starvation underwent a gradual increase of resistance, which was considerably more evident in the resistant strains. When the effect of starvation was combined with 40-min culture in complete liquid medium, the change by a sensitive strain was nil, but a further increase in resistance occurred in the resistant strains. (BBB)

**20442** RADIATION SENSITIZATION BY THIOL-BINDING AGENTS OF RADIORESISTANT AND RADIOSENSITIVE ESCHERICHIA COLI AND THE OXYGEN EFFECT. Moroson, Harold; Tenney, Doreen N. (Sloan-Kettering Inst. for Cancer Research, New York). Radiat. Res., 36: 418-40(Dec. 1968).

Dose-survival curves of four strains of E. coli — B/r hcr$^-$ try$^-$, B$_{s-1}$, B/r CSH, and 15T$^-$ — were obtained in the presence and in the absence of nontoxic levels of several thiol-binding agents — N-ethylmaleimide (NEM), iodoacetamide (IA), and hydroxymercuribenzoate (HMB). The degree of radiosensitization by these agents was estimated from the increase in slope of the dose-survival curve, under anoxic and aerobic conditions. Chemical sensitization of both radioresistant and radiosensitive strains of bacteria with the thiol-binding enzyme poisons NEM, IA, and HMB was observed. NEM sensitized only under anoxic conditions, IA sensitized under both anoxic and aerobic conditions, although to a much greater extent aerobically, and HMB sensitized only under aerobic conditions. The formation of long-lived radiolytic products toxic to bacteria was observed in sensitization by IA. When sensitization occurred, the magnitude of the dose-modifying factor was equal to or greater than the oxygen enhancement ratio. Inhibition of an energy-requiring enzymic repair process did not seem to be involved as a primary mechanism of sensitization. Interference by thiol-binding agents with a rapid repair process, which was different from the usual enzymic re-

pair, and which operated in radiosensitive as well as in radioresistant bacteria was suggested. (auth)

**20443** X-IRRADIATION OF IRRADIATED AND CONTROL POPULATIONS OF PSEUDOMONAS AERUGINOSA UNDER CONTROLLED OXYGEN CONCENTRATIONS. van Soestbergen, A. A. (Ohio State Univ. Hospitals, Columbus). Int. J. Radiat. Biol., 14: 287-91(1968).

Investigations were carried out to determine whether there was increased radiosensitivity in bacteria surviving an x-ray dose. Samples from suspensions of Pseudomonas aeruginosa were exposed to a fixed dose of x radiation at various oxygen concentrations. The percentage of organisms surviving was determined and the results were analysed by the probit method. (F.M.M.)

**20444** PHOTOREACTIVATION SPECTRA FOR PROPHAGE-INDUCING UV DAMAGE AND DELAYED APPEARANCE OF INDUCED PROPHAGE IN ESCHERICHIA COLI. Iwo, Kazuhiro (Osaka Univ.). Idengaku Zasshi, 43: 257-70(Aug. 1968).

In this paper, the action spectra for photoreactivation (PR) of prophage-inducing lesions in two E. coli strains possessing and lacking photoreactivation enzyme activity and a quantitative analysis of the delayed appearance of prophage induction in UV-irradiated $B_{s-1}$ (80) cells are described. Serum against $\phi$80 hb particles, various media and buffer are used. Cells used for the PR treatment were at late lag phase and exposed to PR-light of various monochromatic wave length from a Bausch & Lomb monochromator in qualtz cuvettes. And, in all other experiments, one-mm thick layers of $3 \times 10^8$ cells per ml. were exposed to UV from two 15W germicidal lamps at dose rates of 0.05 erg/mm$^2$/sec for $B_{s-1}$ (80) or 10 erg/mm$^2$/sec for other strains. To assay the number of induced cells, PA method and/or SEM method were employed. The action spectra for photoreversal of prophage induction by UV were strikingly similar in shape to the spectra for PR of mutation to protprophy. There are significant differences in the characters of PR of mutation and prophage induction. Prophage-inducing UV damage in $B_{s-1}$ becomes insensitive to PR treatment much earlier during post-UV incubation than lethal damage. $B_{s-1}$ was not more sensitive to UV killing than non-lysogenic parent $B_{1-1}$ in spite of the high efficiency of prophage induction. Prophage induction occurs only in killed cells and in surviving cells as "fractional" induction, i.e., lysogenic cells divide before lysis yielding both infective centers as well as surviving colonies. The majority of the "fractionally" induced surviving cells at low doses are converted to "fractionally" induced killed cells in high doses. Majority of UV lesions serve to switch on the initiation of prophage induction process but later on become repaired so that the initiation step remains being switched on but cells regain the capacity for phage maturation. (NSA of Japan)

**20445** ORGANIC PEROXIDES AND THE ANTIBACTERIAL ACTION OF IRRADIATED SUCROSE AS AFFECTED BY CATALASE. Schubert, Jack; Watson, Joseph A. (Univ. of Pittsburgh). Contract AT(30-1)-3641. Radiat. Res., 37: 531-8(Mar. 1969).

Sucrose solutions irradiated in the presence or absence of oxygen inhibit the growth of Salmonella typhimurium. The addition of catalase prior to or shortly after inoculation of the organisms into the growth medium containing irradiated sucrose eliminates most of the inhibitory action produced by irradiated oxygen-free sucrose solutions and only partly eliminates inhibition manifested by irradiated oxygenated sucrose solutions. The effectiveness of catalase decreases when the time elapsed between inoculation and addition of catalase is increased, but is time-independent when catalase is added before inoculation. The inhibitory action of irradiated sucrose is attributed to hydroxyalkyl peroxides, R(OH)-OO-H and R(OH)-OO-(OH)R, formed from the interaction of radiolytic $H_2O_2$ with carbonyl compounds resulting from carbohydrate radiolysis. From mass action and other considerations it is concluded that the hydroperoxides predominate in irradiated oxygen-free sucrose, while the dialkyl peroxides predominate in irradiated oxygenated sucrose solutions. (auth)

**20446** SENSITIVITY TO ULTRAVIOLET LIGHT OF RNA SYNTHESIS UNDER DIFFERENT CULTURE CONDITIONS IN PSEUDOMONAS EFFUSA. Atsuta, Joe; Okajima, Shunzo (Nagasaki Univ.). Radiat. Res., 37: 636-52(Mar. 1969).

Comparative studies were made on the sensitivity of the synthesis of individual ribonucleic acids (RNA) components to ultraviolet light (UV) under conditions that (A) suppressed ribosomal RNA (rRNA) synthesis and permitted preferential synthesis of messenger RNA (mRNA); (B) permitted balanced synthesis of individual RNA components; and (C) suppressed mRNA synthesis and permitted preferential synthesis of rRNA. Under condition A, mRNA synthesis was found to be much more UV-sensitive in the presence than in the absence of inducer. Under condition B, no preferential inhibition of the synthesis was observed for any one of the mRNA peaks. Synthesis of rRNA was more readily found to be UV-sensitive with the increasing molecular weight of RNA under condition C than under condition B. (auth)

**20447** PHOTOCHEMISTRY OF A MACROMOLECULE: TOBACCO MOSAIC VIRUS. McLaren, A. D. (Univ. of California, Berkeley). Photochem. Photobiol., 8: 521-5(Dec. 1968).

A history of the photochemistry of the first known virus is presented. Hollaender and Duggar recognized that the virus contains nucleic acid because of the shape of their action spectrum for photoinactivation. An analysis of this spectrum in detail presents a challenge to photochemists because of the combined role of protein and nucleic acid in determining rates of inactivation. At present these rates cannot be explained simply on the basis of the photochemistry of each of the constituents; that is, the photochemistry of free infectious nucleic acid differs in several respects from that exhibited by nucleic acid irradiated in intact virus. It is believed that pyrimidine hydrate and dimer formations are important, but an explicit solution to the problem is not in sight. (auth)

**20448** EFFECTS OF $\gamma$ IRRADIATION ON ESCHERICHIA COLI WILD TYPE AND ITS RADIORESISTANT MUTANTS. II. POST-IRRADIATION DEGRADATION OF DNA. Stavric, S.; Dickie, N.; Thatcher, F. S. (Dept. of National Health and Welfare, Ottawa). Int. J. Radiat. Biol., 14: 411-16(Dec. 1968).

The degradation of DNA after irradiation was determined in Escherichia coli wild type (parent) and three radioresistant mutants 1$\gamma$, 6$\gamma$ and 12$\gamma$ by measuring the loss of radioactivity from cells previously labeled with [$^3$H] thymidine. Large differences existed in rates and extent of DNA degradation among the bacterial strains. The maximum degradation was approximately 70 percent in the parent strain, 50 percent in the 1$\gamma$ strain and 15 percent in the 6$\gamma$ and 12$\gamma$ strains. (auth)

**20449** EFFECTS OF $\gamma$ IRRADIATION ON ESCHERICHIA COLI WILD TYPE AND ITS RADIORESISTANT MUTANTS. I. POST-IRRADIATION SYNTHESIS ON DNA. Stavric, S.; Dickie, N.; Thatcher, F. S. (Dept. of National Health and Welfare, Ottawa). Int. J. Radiat. Biol., 14: 403-10(Dec. 1968).

Exponentially growing cells of Escherichia coli wild type and three radioresistant mutants, E. coli 1$\gamma$, 6$\gamma$, and 12$\gamma$, derived therefrom, were exposed to $\gamma$ irradiation and DNA synthesis after irradiation was determined by measuring [$^3$H] thymidine incorporation. Irradiation at relatively low doses (10 to 30 krads) resulted in: a permanent reduction of 70 to 90 percent in the rate of DNA synthesis in E. coli wild type ($D_{37}$ = 4 krads) and 1$\gamma$ ($D_{37}$ = 20 krads); temporary inhibition in E. coli 12$\gamma$ ($D_{37}$ = 35 krads); and about 20 percent stimulation in the most radioresistant strain E. coli 6$\gamma$ ($D_{37}$ = 50 krads). After higher doses (50 to 100 krads), synthesis of DNA in the 6$\gamma$ strain was temporarily inhibited and resumed within one normal generation time at the same rate as in the unirradiated control. Resumption of DNA synthesis in irradiated cells of E. coli 12$\gamma$ was further delayed in this dose range. (auth)

**20450** 2,3-BUTANEDIONE, AN ELECTRON-STABILIZING COMPOUND, AS A MODIFIER OF SENSITIVITY OF BACILLUS MEGATERIUM SPORES TO X-RAYS. Tallentire, A.; Schiller, N. L.; Powers, E. L. (Univ. of Texas, Austin). Contract AT-(40-1)-3408. Int. J. Radiat. Biol., 14: 397-402(Dec. 1968).

The organic compound 2,3-butanedione (diacetyl) has a high affinity for free electrons, and can stabilize electrons produced by high-energy radiations in aqueous solutions. In the non-metabolizing spore of Bacillus megaterium (buffer suspension at pH 7.0), this compound increased radiosensitivity in the absence of oxygen as concentration increased up to approximately $4 \times 10^{-3}$ M. The maximal increase represented 40 percent of the total observed in the full oxygen effect. Since the compound at maximally effective concentration in the presence of oxygen does not increase radiosensitivity above that level seen in oxygen alone, it is allowed that the potentiating action of the compound represents one of the actions of oxygen, i.e., oxygen may act in part by stabilizing electrons. Above about $6 \times 10^{-3}$ M the effectiveness of the compound as a sensitizer decreased, until the anoxic level of sensitivity was reached at $6 \times 10^{-2}$ M. No suggestions concerning this reversal of effect at high concentrations were offered. (auth)

## Radiosterilization and Radiopreservation

**20451** PRESERVATION OF FRESH UNFROZEN FISHERY PRODUCTS BY LOW-LEVEL RADIATION. 6. OPTIMUM

RADIOPASTEURIZATION DOSE STUDIES ON OCEAN PERCH, POLLOCK, AND COD FILLETS. Ampola, Vincent G.; Connors, Thomas J.; Ronsivalli, Louis J. (Bureau of Commercial Fisheries Technological Lab., Gloucester, Mass.). Food Technol., 23: 83-5(Mar. 1969).

The feasibility of radiopasteurizing ocean perch, pollock and cod fillets was demonstrated. Organoleptic tests indicated that with air-packed pollock and cod fillets, an irradiation dose level of 150 krads was effective in extending the shelf life of the product for up to 30 days when the product was stored at about 1°C. It should be noted, however, that when the product was deep-fat-fried, its acceptability was markedly greater than when the product was steamed. With ocean perch fillets, a dose of 250 kilorads was required for the same effect, although some panelists indicated they detected rancidity. The value of vacuum packing in reducing necessary radiation dose was also studied. (C.O.)

**20452** IRRADIATION OF CULTURED MUSHROOMS. Gill, W. J.; Nicholas, R. C.; Markakis, P. (Michigan State Univ., East Lansing). Food Technol., 23: 111-14(Mar. 1969).

Gamma radiation retards the rate at which cultured mushrooms (Agaricus bisporus, Sing.) open during storage: 10 krad appreciably reduces the normal increase in cap diameter, 20 to 50 krad is required for effective reduction in the shrinking of the stem diameter, 100 krad or more to prevent lengthening of the stem. The rate of darkening is decreased by radiation; texture remains good at doses below 200 to 500 krad. The parameters, Opening Ratio and Degree of Opening, are defined and used to measure quality changes in the temperature range 3 to 15°C. Slight losses in the suppressing effects of radiation appear when there is a delay between harvest and irradiation. (auth)

**20453** INVESTIGATIONS OF THE STERILIZATION OF SALT MEAT PRODUCTS BY IRRADIATION. Asdrubali, Giampaolo (Univ., Milan. Univ., Perugia, Italy). Vet. Ital., 17: 107-22(1966). (In Italian and English).

Samples of sliced cooked ham and mortadella in vacuum sealed containers were treated with $^{60}$Co $\gamma$ radiation alone or in combination with pasteurization. Ham was sterilized by doses of 0.5 Mrad and mortadella by 0.3 Mrad plus pasteurization (65°C for 15 min). These doses did not produce the undesirable organoleptic properties observed after higher doses. It is concluded that radiosterilization is feasible for sliced salt pork products. (M.M.B.)

**20454** NEW METHOD OF THE STERILIZATION OF ARTIFICIAL HONEYCOMB WITH $^{60}$Co gamma RAYS. Smirnov, A. M. Dokl. Vses. Akad. Sel'skokhoz. Nauk, No. 5, 34-6(May 1966). (In Russian).

Sterilization experiments were conducted in 1964-5 to free artificial honeycombs from the causative agents of foul brood, a destructive bacterial disease of the larvae of the honeybee. Cultures of European strains such as Bacillus alvei, Streptococcus apis, and Bacillus pluton were prepared from dead larvae, in addition to the American strains of Bacillus larvae. A $^{60}$Co $\gamma$-ray source was used for 26 irradiation experiments at doses from 500,000 R to 5 MR at 600 R/min, 950 R/min, and 2120 R/sec. Concentrations of 1-, 2-, 5-, and 10-billion microorganisms in 5- to 10-ml suspensions of each species were inserted in glass test tubes and exposed to radiation. The results of irradiation were checked by inoculations on various culture media in 10 to 24 hr after the exposure, and after 3, 7, 10, 15, and 30 days following irradiation. It was found that natural and artificial honeycombs, packed tightly in marketable bundles ready for shipment or storage, were completely sterilized after application of $^{60}$Co $\gamma$-ray total radiation doses from 2.5 MR and higher. Total doses of 800,000 R of $\gamma$ rays were sufficient to destroy B. alvei and B. larvae strains. Total $\gamma$-ray radiation doses lower than 600,000 R given at 600 R/min induced the development of new colonies of bacterial mutants of the tested basic strains. (BBB)

**20455** INDUCED STERILIZATION AND CONTROL OF INSECTS. Proverbs, M. D. (Canada Dept. of Agriculture, Summerland, B. C.). Annu. Rev. Entomol., 14: 81-102(1969).

Use of ionizing radiation and other agents to sterilize insects for use in control programs is reviewed, with 151 references. The cytological effects of radiation and many chemosterilants are seemingly alike. The severity of radiation and chemosterilant injury to germ cells may be influenced by factors such as temperature, oxygen tension, genetic make-up of the insect, and its age and stage of development. Chromosome injury by radiation and certain chemicals is presumably the same in somatic cells as in germ cells, and may lead to cell death. Chromosome aberrations are induced most easily in interphase cells that are preparing for division. Therefore, where there is much proliferating tissue present, as at certain times in larval development, more somatic injury results. Cytoplasmic injury may also result in cell death. Such injury may be caused by alkylating chemosterilants or by radiation. Cytoplasmic killing by $\alpha$ particles is 16 million times more difficult than nuclear killing in Bracon eggs. Methods of retaining vigor of radiation-sterilized insects are discussed. Much higher doses of radiation are needed to sterilize Lepidoptera than Diptera and most other insects. These high doses are believed responsible for the frequently observed reduction in sexual vigor of irradiated moths and butterflies. Unlike the Diptera, Lepidoptera have chromosomes with diffuse centromeres. Consequently, when a moth or butterfly is irradiated, most of the pieces from broken chromosomes are not lost during division, for each piece has its own site of attachment. To induce dominant lethality in these insects, it is probably necessary to use radiation doses that are sufficiently high to cause 2 or more chromosome breaks. It is suggested that combinations of chemosterilants with radiation might induce sterility without reducing vigor. Other possible methods of retaining the vigor of irradiated insects are discussed. (BBB)

**20456** REDUCTION OF THE MICROBIAL POPULATION OF APPLE CIDER BY ULTRAVIOLET IRRADIATION. Harrington, W. O.; Hills, Claude H. (Dept. of Agriculture, Philadelphia). Food Technol., 22: 117-20(Nov. 1968).

The effect of uv irradiation on microbial count, storage life, and flavor of freshly pressed apple juice was studied. After irradiation of fresh nonclarified apple cider, the total microorganism count was reduced and the cider's cold storage life was extended. Portions of cider were pumped at a rate of 73 gph through 3 uv lamp series 1, 2, 3, or 4 times. Each uv treatment reduced the total viable microbial counts by about 80%. There was no visible fermentation in any of the samples at 20 days of storage. The control and the 13.5-sec uv treatment samples were actively fermenting after 35 days in cold storage. The total count of the longer uv-treated ciders increased but no off-flavors or other changes were noted. The results of a taste panel test for flavor difference between uv-irradiated fresh cider and nonirradiated controls showed no differences. (BBB)

**20457** RADIATION STERILIZATION AND THE EFFECT OF MULTIPLE MATING OF FEMALES IN GLOSSINA AUSTENI. Curtis, C. F. (Univ. of Bristol, Langford, Eng.). J. Insect. Physiol., 14: 1365-80 (Oct. 1968).

Adult males of the tsetse species Glossina austeni were $\gamma$ irradiated with $^{60}$Co to doses of 1 to 12 KR and mated with untreated females. The relation of dose to percentage of sperm with induced dominant lethals was established. When individual females were mated to both a sterilized and a fertile male, sperm from whichever mating was made first was used predominantly, but not exclusively, for fertilization. Sterile and fertile sperm were equally competitive for fertilization, but the fertility/unit time of the females mated to both types of male was just significantly higher than would have been expected on the basis of the relative number of eggs fertilized by each type of sperm. This is explained by the fact that the early death of an embryo in the uterus leads to a 2-day advancement in the time of the next ovulation. It was concluded that the extent to which this consequence of viviparous reproduction would reduce the efficiency of the sterile male method against flies would be relatively trivial. (BBB)

**20458** RADIATION STERILIZATION OF PREFRIED COD AND HALIBUT PATTIES. Sinnhuber, R. O.; Landers, Mary K.; Yu, T. C. (Oregon State Univ., Corvallis). Food Technol., 22: 74-6(Dec. 1968).

Prefried, heat-and-serve seafood products were developed that would withstand room-temperature storage for 1 yr after radiation sterilization. The storage stability of the products and the effect of the addition of antioxidants were determined by preference panels and color measurements. The breaded prefried cod and halibut patties were irradiated at 4.5 Mrad at ambient temperature and stored for 12 months at 22°C with periodic evaluations to assess quality and the effect of antioxidants added to the fish flesh. According to flavor preference panels consisting of 144 to 180 judges, there were no significant differences in flavor between the nonirradiated control samples held at −18°C and the irradiated fish patties (with or without added antioxidants) that had been stored for 6 months at 22°C. Although the nonirradiated fish patties were preferred to the irradiated patties after 12 months storage, the scores, with one exception, were on the like side of the hedonic scale. The serving of an adjunct with irradiated prefried halibut patties significantly improved flavor scores. The color reflectance values seemed to be a reliable measure of the length of storage and the degree of browning of the radiation-sterilized seafood products. Antioxidants did not materially

improve flavor scores or slow the browning reaction of prefried cod patties but showed a favorable effect on halibut patties. (BBB)

**20459** RADIOSENSITIVITY AND REGULATION OF POPULATION DENSITY IN THE YELLOW FEVER MOSQUITO (AEDES AEGYPTI). Willard, William K. (Univ. of Tennessee, Knoxville). Radiat. Res., 37: 493-8(Mar. 1969).

Populations of the yellow fever mosquito, Aedes aegypti (L.), were exposed to a series of selected levels of x-rays (0 R, 1600 R, 3200 R, and 6400 R). Females mated with irradiated males produced a normal complement of eggs regardless of the dose administered to the males; however, the viability of the eggs decreased with increasing dose to the males. Nontreated females mated with irradiated males (6400 R) produced eggs that were only 0.0005% viable. Females treated with 3200 R and mated with nontreated males failed to produce eggs. Sterile individuals of either sex or both sexes were introduced into nontreated populations having a sex ratio of 1:1. The introduction of sterile males was more effective as a population control method when the percentagewise variation in egg viability was considered; however, the number of individuals produced was 11% less when sterile females were introduced than was found with the comparable introduction of sterile males. The more practical means of population control of Aedes aegypti was concluded to be the introduction of sterile males. Contrary to observations in many species, the females were twice as sensitive to radiation as were the males when compared on the basis of the dose required to sterilize and with regard to the production of viable eggs. (auth)

**20460** CAN ATOMIC ENERGY PROTECT FOOD FROM DECAY. Bramlage, William J.; Couey, H. Melvin; Lipton, Werner (Dept. of Agriculture, Fresno, Calif.). Agr. Marketing (Washington), 12: 8-9(Jan. 1967).

Results of irradiation preservation tests on 22 fresh fruits and vegetables are reported. Market life of strawberries, figs, and mushrooms was extended several days in some varieties, but the color, taste, firmness, ripening, and decay susceptibility were impaired by irradiation in apples, avocadoes, grapes, nectarines, olives, oranges, peaches, pears, plums, bell peppers, canteloupes, cucumbers, globe artichokes, lettuce and endives, summer squash, sweet corn, sweet potatoes, and tomatoes. The samples used were relatively large and usually included more than 1 variety of fruit or vegetable. Holding tests that simulated commercial shipment were performed, and actual transcontinental shipping tests were performed with oranges and potatoes. (BBB)

# METALS, CERAMICS, AND OTHER MATERIALS

## Metals and Alloys

*Refer also to abstract 19744.*

**20461** (BMI–1857) PROGRESS ON DEVELOPMENT OF MATERIALS AND TECHNOLOGY FOR ADVANCED REACTORS DURING OCTOBER–DECEMBER 1968. Quarterly Report, Tasks 6, 7, and 14. Keller, Donald L. (Battelle Memorial Inst., Columbus, Ohio). Jan. 1969. Contract W-7405-eng-92. 102p. Dep. CFSTI.

Information in the report is presented in three sections. A separate abstract was prepared for each of the three sections. (F.S.)

*For abstracts of individual sections see: 20516, 20530, and 20546.*

**20462** FIELD-ION MICROSCOPY. Hren, John J.; Ranganathan, S. (eds.). New York, Plenum Press, 1968. 255p.

Information in the book is presented in twelve chapters and seven appendixes. A separate abstract was prepared for each of two chapters. Chapters for which no abstracts were prepared are concerned with theory of field ion microscopy, field emission and ionization, field evaporation, gas impact, geometrical aspects, nonrefractory metals, defects, interfaces, experimental studies, and whiskers. The appendixes contain a bibliography information on lattice geometry, a table on crystallographic planes, stereographic projection diagrams, microscopy indexing, a table on polishing, and microscope designs. (J.R.D.)

*For abstracts of individual chapters see: 20515 and 20529.*

**20463** REACTOR MATERIALS. Volume 12, Number 1. Simons, E. M.; Porembka, S. W. Jr.; Keller, D. L. (eds.). One of Four Quarterly Technical Progress Reviews Published for the Division of Technical Information, USAEC. Columbus, Ohio, Battelle Memorial Institute, Spring 1969. 74p. GPO $0.70.

Research and development progress on materials is presented in four sections. A separate abstract was prepared for each section. (F.S.)

*For abstracts of individual sections see: 20464, 20465, 20494, and 20531.*

**20464** FUEL AND FERTILE MATERIALS. Reactor Mater., 12: 1-15(Spring 1969).

A summary and review are presented of research and development on U and U alloys, Pu and Pu alloys, and Th and Th alloys. Information on the development of metal-ceramic and coated-particles and the behavior and properties of fuel carbides, oxides and nitride fuels is included. Radiation effects on ceramic and metallic fuels are reported. 76 references are included. (F.S.)

**20465** CLADDING AND STRUCTURAL MATERIALS. Reactor Mater., 12: 25-59(Spring 1969).

Data and information resulting from research are reported on corrosion of reactor cladding and structural materials by aqueous and gaseous mediums, nonaqueous liquids, and vapors. Information is included on metal-water reactions and radiation effects on structural materials. Information is also presented on the metallurgy of refractory metals and less common cladding and structural materials. Information on new developments related to diffusion are reviewed along with information on concrete and ceramic technology. (J.R.D.)

### Corrosion and Erosion

*Refer also to abstracts 20524, 20534, and 21475.*

**20466** (CEA-CONF–1052) PROTECTION OF ZIRCONIUM AND ITS ALLOYS BY CLADDING. Loriers, H.; Lafon, A.; Darras, R.; Baque, P. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). [1968]. 33p. (In French). (CONF-680539–3). Dep.

From 50th Anniversary of the Society of Industrial Chemistry, Paris, France.

Zirconium and its alloys are corroded by $CO_2$ at about 600°C as shown by formation of a surface layer of zirconium oxide and embrittling dissolution of oxygen in the substrate alloy. These corrosion processes limit the use of zirconium alloys in fuel cans for nuclear reactors cooled by $CO_2$. Attempts were made to minimize the effects of the corrosion of zirconium under these conditions by cladding protection. Electrodeposited claddings of chromium, the adherence of which was improved by heat treatment under vacuum, proved to be efficient. A similar result was obtained with molybdenum cladding produced by the technique of vaporization by high-frequency inductive plasma. The efficiency of these two types of cladding is explained by their constitutions, characterized by the maintenance of an adhering film of chromium or molybdenum in the free state. (tr-auth)

**20467** (CEA-CONF–1053) PROTECTION OF URANIUM BY CLADDING. Baque, P.; Koch, P.; Dominget, R.; Darras, R. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). [1968]. 57p. (In French). (CONF-680539–2). Dep.

From 50th Anniversary of the Society of Industrial Chemistry, Paris, France.

Studies were made on the possibilities of inhibiting or limiting the oxidation of uranium by $CO_2$ at high temperatures by means of protective cladding. Success is usually obtained with the composition of the surface film based on intermetallic compounds or solid solutions of uranium with aluminum, zirconium, copper, niobium, nickel, or chromium according to various techniques described. The processes of direct diffusion starting with a thin film or foil, evaporation under vacuum, or immersion in molten baths of suitable composition appear to be particularly satisfactory. The most suitable conditions for using these claddings for the purpose of protection are in $CO_2$ at 450 to 500°C. Only the claddings with aluminum base or of zirconium proved to be entirely satisfactory, for they are capable of reducing the oxidation of uranium under the conditions considered, and to inhibit the liberation of powdered oxide. Furthermore, the claddings obtained generally assure good protection of uranium against atmospheric corrosion. (tr-auth)

**20468** (N–68-34022) CHEMICAL VAPOR DEPOSITION OF CHROMIUM ON $ThO_2$. Final Report. Veigel, Neil D.; McCall, J. L.; Meiners, K. E.; Blocher, J. M. Jr. (Battelle Memorial Inst., Columbus, Ohio). June 30, 1968. Contract NAS3-10492. 92p. (NASA-CR–72404). CFSTI.

A process was developed to prepare small (5 to 16-gram) quantities of high-purity chromium–$ThO_2$ powder by deposition of chromium on and/or in the presence of entrained particles of $ThO_2$. To obtain high-purity chromium, the hydrogen reduction of $CrI_2$ was used as the coating reaction. On consolidation of the vapor-formed product by hot isostatic pressing, a fair dispersion of $ThO_2$ was obtained which appears to be stable at 2600°F for 100 hours, as evidenced by the fact that coalescence was limited to local modification of the $ThO_2$ agglomerates present in the as-pressed condition. Migration of individual $ThO_2$ particles or agglomerates did not occur. However, both agglomerates and individual particles were spheroidized on heat treatment at 2600°F. (auth) (STAR)

**20469** (ORNL–4350, pp 87-139) ALKALI-METAL CORROSION STUDIES. (Oak Ridge National Lab., Tenn.).

Recent results from the program to investigate the chemical and metallurgical effects produced in reactor structural materials during exposure to alkali metals are reported. Refluxing capsules of W-base-26% Re were tested in K for 5000 hrs at a boiler-condenser temperature of 1250°C. A capsule fabricated by powder metallurgy methods showed no measurable corrosion effects but one from arc-melted material contained a crystalline deposit of almost pure W. A natural circulation K loop of TZM alloy was operated at 1200°C for 4400 hrs, until a creep failure occurred in the vapor line. The effects of oxygen on the compatibility of alkali metals and refractory metals for the TA-O-K system at 800 and 1000°C were evaluated. Penetration by K occurred in all but one specimen of the test series; preferentially along grain boundaries. It is believed that attack proceeded with formation of a ternary oxide which dissolved in K as the system approached equilibrium. Tests are being conducted in static capsules at 600°C on the systems Nb-O-K, Ta-O-K, Nb-O-Na, Ta-O-Na, Nb-O-Li, and Ta-O-Li. Lithium thermal convection loop tests, to study mass transfer of refractory metals, were terminated after a 3000 hr run. The loop of Ta-base alloy T-222 was operated at a maximum boiling temperature of 1350°C. Weight change results, analogous to those observed for Nb–1% Zr and D-43 alloys, are tabulated. A significant transfer of Hf from the hotter to the cooler loop surfaces was observed in which the profile of Hf surface concentration mirrored the weight-change profile. Design and fabrication methods for circulation loops and control specimen units are described. (auth)

**20470** PREVENTION OF SEIZING IN LIQUID METAL ENVIRONMENTS. Gurinsky, D. H.; Powers, R. M.; Sussking, H. (to United States Atomic Energy Commission). U. S. Patent 3,429,774. Feb. 25, 1969.

A method of preventing seizing of stacked stainless steel elements in a liquid sodium environment utilizes, in the steel, a deoxidant selected from the group consisting of titanium, niobium, and aluminum. (AEC)

**20471** USE OF RADIOISOTOPES IN STUDIES OF PASSIVATION AND CORROSION. Wormwell, F.; Thomas, J. G. N. (National Physical Lab., Teddington, Eng.). Soc. Chem. Ind. (London), Monogr., No. 28, 365-82(1968).

From Conference on Surface Phenomena of Metals, London, Eng. See CONF-670978-4.

Radiotracer techniques for the determination of the uptake of substances from solution on to metal surfaces are surveyed. The information derived from the use of these techniques is discussed with reference to the role of anion adsorption on metal surfaces in influencing (a) metal dissolution in the active state, (b) the transition from the active to the passive state, (c) the growth of passivating films and (d) the breakdown of passivating films. (auth) (UK)

**20472** STUDY OF CHEMISORPTION AND SURFACE REACTIONS BY FIELD ION MICROSCOPY. Anderson, J. S. (Oxford Univ.). Soc. Chem. Ind. (London), Monogr., No. 28, 109-27(1968).

From Conference on Surface Phenomena of Metals, London, Eng. See CONF-670978-2.

The use of field emission and field ion microscopy for investigating the tungsten–oxygen system is discussed, and results are compared with some for tungsten–nitrogen and with published low-energy electron diffraction results. (auth) (UK)

**20473** INFLUENCE OF SURFACE FILMS ON THE WETTING OF TRANSITION METALS BY MOLTEN SODIUM. Addison, C. C.; Iberson, E.; Pulham, R. J. (Univ. of Nottingham, Eng.). Soc. Chem. Ind. (London), Monogr., No. 28, 246-62(1968).

From Conference on Surface Phenomena of Metals, London, Eng. See CONF-670978-1.

Receding contact angles for molten sodium on nickel, cobalt, iron, molybdenum, tungsten, vanadium, niobium, tantalum, titanium, and zirconium in an argon atmosphere were studied as a function of time and temperature. Observations are correlated on the basis that the changes in contact angle reflect the reaction with sodium of the invisible oxide film present on the transition metal surfaces after abrasion to a mirror surface in air. Ni, Co, Fe, Mo, and W show a critical wetting temperature below which no wetting occurs and below which it is believed that no reduction of the oxide film occurs. The behavior of these metals is compared with that of vanadium, niobium, tantalum, titanium, and zirconium, for which no critical wetting temperature is observed. The formation of double oxides at the solid metal/liquid sodium interface is proposed to explain the wetting behavior. (auth) (UK)

**20474** SURFACE PHENOMENA OF METALS, HELD ON 20–22 SEPTEMBER, 1967, AT BRUNEL UNIVERSITY, ACTON, LONDON, ENGLAND. Society of Chemical Industry Monograph No. 28. London, Society of Chemical Industry, 1968. 486p. £5.10s. (CONF-670978).

A total of 27 papers was presented at the conference. A separate abstract was prepared for each of four papers. Papers for which no abstracts were prepared are concerned with metal surfaces, single crystals, sublimation, alloy colors, chemisorption, monomolecular films, Hg–Pd reactions, sorption of O and S by Cu and Ag, sorption of alcohol by iron, Au sorption by W, sintering, metal-glass reactions, oxidation films, nitridation, dropwise condensation, fracture surface changes, and corrosion resistant stainless steel. (J.R.D.)

*For abstracts of individual papers see: 20471–20473 and 20502.*

**20475** OXIDATION OF PURE Be IN $CO_2$ AT HIGH TEMPERATURES. Nisigaki, Susumu (NGK Insulater Co., Ltd., Nagoya, Japan); Kondo, Yasuko; Nagasaki, Ryukichi. Nippon Kinzoku Gakkaishi, 33: 134-40(1969). (In Japanese).

Pure Be was oxidized in flowing $CO_2$ at 550 to 700°C. The observed feature of kinetic discontinuity was explained in terms of oxide morphology. The initial cubic rate results from the formation of an outer thin BeO film and the subsequent growth of the oxide crystallite coherent to the orientation of the underlying metal. The second stage, parabolic, is observed when the oxide loses the crystallographic coherency to the metal and grows as coarse crystals toward the [10$\bar{1}$0] direction with their (0001) plane parallel to the oxidizing surface. (auth)

**20476** CORROSION-RESISTING COBALT–CHROMIUM–TUNGSTEN ALLOY. Baumel, Anton (to Gebr. Bohler and Co.). U. S. Patent 3,425,827. Feb. 4, 1969. Priority date Oct. 29, 1963, Austria.

In a cobalt-chromium-tungsten alloy a portion of the cobalt is substituted with from 2.5 to 20% nickel to markedly increase the corrosion resistance of the alloy. (Offic. Gaz.)

**20477** STUDIES ON THE LOW TEMPERATURE AQUEOUS CORROSION OF MILD STEEL UNDER REACTOR RADIATION. PART 2. RESULTS FROM 18 MONTHS' EXPOSURE OF SPECIMENS TO THE LOOP WATER. Whittle, I.; Gerrish, M. E.; Hill, S. S. (Central Electricity Generating Board, Berkeley, Eng.). J. Brit. Nucl. Energy Soc., 8: 78-82(Jan. 1969).

The results are described of an investigation into the low-temperature corrosion of mild steel under reactor radiation in water simulating that of concrete pressure vessel cooling systems. General corrosion rates were ≈0.001 in. metal penetration in 30 years. Crevice corrosion was negligible. Corrosion under irradiation was less than that out of the radiation field. The work has shown that such cooling systems will behave satisfactorily in service. (auth) (UK)

## *Preparation and Fabrication*

*Refer also to abstracts 19703, 19718, 19746, 19846, 19878, 20466, 20505, 20506, 20524, 20549, and 21566.*

**20478** (NLCO-1032) EXPERIMENTAL USE OF A LASER TO PENETRATE URANIUM. Spitz, H. Y. (National Lead Co. of Ohio, Cincinnati). Mar. 1969. Contract AT(30-1)-1156. 14p. Dep. CFSTI.

A theory was developed to predict the amount of material excavated from a uranium target by a laser beam. Experimental data, obtained by use of a pulsed $CO_2$ laser, confirmed the theoretical predictions and demonstrated that penetrability decreased with increasing hardness of the target. (auth)

**20479** (ORNL-4334, pp 3-9) INHOMOGENEOUS DISTRIBUTION OF TANTALUM AND TUNGSTEN IN ZONE-REFINED NIOBIUM. Reed, R. E. (Oak Ridge National Lab., Tenn.).

Autoradiographs, using $\beta^-$ emission, from neutron-activated Ta and W impurities in zone-melted Nb, indicate that these impurities are inhomogeneously distributed, and that they lie in alternate layers of impurity "rich" and "poor" regions that are parallel to the moving liquid-solid interface during melting. (P.G.C.)

**20480** (ORNL-4350, pp 79-83) ZIRCONIUM METALLURGY. (Oak Ridge National Lab., Tenn.).

The study of fabrication procedures used to produce zirconium alloy tubing and their interactions with crystallographic deformation modes continued. Grain sizes of sixteen specimens of tube-reduced and annealed Zircaloy-4 tubing are tabulated and circumferential texture variations and texture gradients in Zircaloy tubing are discussed from the viewpoint of the effects of previous methods of forging, extrusion, and reduction to size, used in processing. (auth)

**20481** (ORNL-4350, pp 229-41) TUNGSTEN METALLURGY. (Oak Ridge National Lab., Tenn.).

Four duplex billets were fabricated from primary W tube shell and Mo bar stock to study the effects of prior work and extrusion preheat on the structure of the final extruded tube. The billets will be extruded at a constant extrusion rate of 3 between 1200 and 1700°C. An alloy of W–5% Re was successfully deposited by the CVD method at 750°C, 10 torr, and a $H_2/(WF_6 + ReF_6)$ ratio of 12. Eighty nine percent of the metal content of the metal fluorides was recovered in the deposit. Measurements of the recrystallization rates of preannealed wrought CVD tungsten and material without a preanneal indicate that the large bubbles (1000 Å) produced by preannealing do not retard recrystallization. This may account for conflicting results obtained on the effects of gas bubbles on recrystallization of irradiated materials. A detailed study was begun to determine the properties, for thermionic applications, of CVD tungsten from $WCl_x$. (P.G.C.)

**20482** (ORNL-4350, pp 249-59) JOINING RESEARCH ON NUCLEAR MATERIALS. (Oak Ridge National Lab., Tenn.).

The fundamental and applied data needed for a better understanding of the weldability of materials used for nuclear applications are investigated. Specific materials include austenitic stainless steels and nickel-rich alloys, as Incoloy 800 and Inconel 600. The application of stainless steels in the Fast Flux Test Facility (FFTF) is emphasized. Investigation of the effect of small variations of minor elements present in structural materials, Al, Ti, S, and P in Incoloy 800, and of S in Inconel 600 continues. Tests

were developed for evaluating weldability of Inconel and the effect of minor impurities on cracking parameters. The program on weldability of Ni-base alloys has been expanded to gain greater insight into the relationship of composition, welding procedures, and weldability. Initial stages of research into the effect of defects on the mechanical properties of weldments have been concerned with producing discontinuities typical of those found in actual weldments, and with devising methods for characterizing the discontinuities. (P.G.C.)

**20483** (ORNL-tr-2108) PREPARATION OF THIN FILMS OF VANADIUM, NIOBIUM, AND TANTALUM FOR NUCLEAR INVESTIGATIONS. Karev, V. N.; Klohcarev, A. R.; Kovalenko, L. I.; Rozen, A. A. Translated for Oak Ridge National Lab., Tenn., from Izv. Akad. Nauk SSSR, Ser. Fiz., 32: 328-31(Feb. 1968). 8p. Dep. CFSTI.

Equipment and procedures for preparing thin films of Nb, Ta, and V by thermal decomposition of $VI_2$, and the pentachlorides and pentaiodides of Nb and Ta on heated substrates are described. For V, a Be substrate was used, and for Nb and Ta, Mo substrates 0.1 mm thickness were used. Deposition of V was observed at ~1230°K which corresponded to the predicted temperature based on thermodynamic calculations but the films were nonuniform and separated from the substrate. Films of Nb and Ta were of uniform thickness and could be separated from the substrate by dissolution of the Mo substrate in dilute $HNO_3$. (P.G.C.)

**20484** (RN-TM-301) XE FLAME SPRAY CAPABILITY TESTS FOR TITANIUM, HASTELLOY, 347 STAINLESS STEEL, AND 6061 T-6 ALUMINUM. Fox, H. A. Jr. (Aerojet-General Corp., Sacramento, Calif. Nuclear Div.). Nov. 1968. Contract SNP-1. 8p. Dep. CFSTI.

Tests were made to determine the interface bond integrity between test material and flame sprayed aluminum. The materials considered were 347 stainless steel, Hastelloy C, and 304 stainless steel that are used for the turbine inlet line (TIL), pump discharge line (PDL), and diluent line (DL) respectively. Because of the similarity of 347 and 304 stainless steels, only 347 was tested. Type 6AL-4V titanium was also included in this test since it is a primary candidate for the NERVA pressure vessel. Additional tests were also conducted on 6061 T-6 aluminum. Since sheathed cables must be mechanically attached to surfaces in a manner which will prevent movement during the subsequent grit blasting and flame spraying operations, additional tests were made to determine a suitable method of cable attachment to these materials. (auth)

**20485** (RT/MET-(68)2) DEVELOPMENT OF FUEL ELEMENT FABRICATION TECHNIQUE FOR URANIUM ALLOYS. Fizzotti, C.; Dalmastri, B. (Comitato Nazionale per l'Energia Nucleare, Rome (Italy)). 1968. 54p. (In Italian). Dep.

The fabrication of a fuel element of the type used in the Latina power plant was studied. The fuel consists of a ternary alloy of U-Mo-Nb or U-Mo-Zr, clad with Al and encased in a Mg alloy cartridge. The fabrication cycle can be divided into three phases: fusion of the rod; thermal treatments, and coating and assembly of the fuel element. Each of these phases is comprised of a series of particular operations and apparatus, which are described. (J.S.R.)

**20486** HIGH STRENGTH PRECIPITATION HARDENING HEAT RESISTING ALLOYS. Kawahata, Masao; Yokota, Kozou; Fukase, Yukishige; Katoh, Shoichi (to Nippon Yakin Kogyo Co., Ltd.). U. S. Patent 3,420,660. Jan. 7, 1969. Priority date Sept. 20, 1963, Japan.

A heat resisting alloy which has a high creep rupture strength, excellent toughness at temperatures up to 800°C, and excellent resistance to oxidation is prepared by adding precipitation hardening elements comprising molybdenum, tungsten, and niobium alone or added with uranium and vanadium, titanium, aluminum, and one or more of the elements boron, zirconium, and/or tantalum to a base alloy having a crystal structure of face-centered cubic containing iron, chromium, nickel and cobalt. (Offic. Gaz.)

**20487** DEVELOPMENT OF NUCLEAR FUELS IN JAPAN: ON THE PRESENT STATUS AND SOME TECHNICAL PROBLEMS. Iwasaki, Koji; Takenaka, Shunzo. Nippon No Kagaku To Gijutsu, 9: No. 9, 12-19(Sept. 1968). (In Japanese).

The general status, future prospects, and programs are described with regard to Japanese research and development on uranium enriching methods, ceramic fuel processing and irradiation, efficient utilization of plutonium in light-water power reactors, and irradiated fuel reprocessing. Basic policies of the Japan Atomic Energy Committee on the establishment of the fuel cycle are also reviewed. As to prospecting and mining of uranium ore, it was stressed that the development of overseas sources be promoted to provide 20,000 tons of uranium according to the 10 year plan of prospecting. This is necessary to supply the demand in nuclear power generation. Some problems of the mining technology are discussed in connection with geologic conditions in Japan and a unique smelting method by which $UF_4$ was obtained directly from ore without intermediate products. (NSA of Japan)

**20488** Zr Hf NEWSLETTER, JANUARY 1969. Akron, N. Y., Amax Specialty Metals, Inc., 1969. 16p.

Recent developments in the metallurgy of Hf, Mo, Nb, V, and Zr are reviewed. Mechanical properties of these metals and their alloys are discussed as are oxidation studies, coatings, phase diagrams, and uses. Other papers deal with hydrides, oxides, carbides, borides, and nitrides, production methods, and physical properties. One hundred and ninety-two references are cited. (P.G.C.)

**20489** PRODUCTION OF PARTICULATE, NON-PYROPHORIC METALS. (to CIBA Ltd.). British Patent 1,141,775. Jan. 29, 1969. Priority date June 25, 1965, Switzerland.

Finely-dispersed non-pyrophoric powders of Hf, Mo, Nb, Ta, Th, U, V, W, or Zr are produced, in a plasma jet, from the metal halides. Preferred use is made of the metal chlorides. The powders have an average particle size of 0.03 to 0.1 $\mu$ with an oxygen content of <3 mg/m$^2$ of surface and are predominantly in the form of cubes, octahedra, or spheres. (P.G.C.)

**20490** IMPROVEMENTS IN MOULDS AND METHODS OF CASTING. (to Howmet Corp.). British Patent 1,144,130. Mar. 5, 1969. Priority date Mar. 22, 1965, United States.

Molds for casting Hf, Cr, Mo, Nb, Ta, Th, Ti, U, V, or W are produced by forming, around a wax or solvent removable pattern, a dip-coat composition of layers of colloidal graphite, graphite flour, or ceramic materials, with the layers immediately surrounding the cavity being impregnated with a high molecular weight organic material, such as one of the liquid resins, which may be decomposed in situ in the walls of the mold to form carbon or other inert carbonaceous material to fill interstices in the mold. (P.G.C.)

**20491** PREPARATION OF METALLIC DYSPROSIUM BY REDUCTION OF ITS OXIDE BY MEANS OF THORIUM. Schiffmacher, Gerard; Trombe, Felix (CNRS, Bellevue, France). Compt. Rend., Ser. C, 268: 159-62(Jan. 13, 1969). (In French).

Examination of some thermodynamic possibilities of reduction and of vapor pressures justifies the use of thorium to reduce the oxides of rare earths. The preparation of dysprosium is then described. The redistillation of the metal obtained, in the presence of thorium, makes it possible to purify it, principally from oxygen. (tr-auth)

**20492** CONTROLLED ELECTRON BEAM EVAPORATION OF BERYLLIUM. McLeod, P. S.; Nordin, C. W. (Dow Chemical Co., Golden, Colo.). J. Phys., E (London), 2: 381(Mar. 1969).

A method of controlling electron-beam evaporation of beryllium utilizing the light emitted by the vapor as a measure of evaporation rate is described. This method was used to give films with thickness accuracies to within three per cent. (auth) (UK)

**20493** HIGH STRENGTH ALUMINUM ALLOY AND ITS PRODUCTION METHOD. Nakamura, Hajime; Hori, Toshimitsu; Sezaki, Kazuo (to Ishikawajima-Harima Jukogyo Kabushiki Kaisha). U. S. Patent 3,429,695. Feb. 25, 1969. Priority date Oct. 12, 1965, Japan.

Production of an Al alloy having high tensile strength and hardness is described. The alloy contains about 0.3 to 1.2 wt % Zr and 6 to 25 cc H/100 g. Heat treating and hot working processes used to induce good mechanical properties are reported. (J.R.D.)

**20494** SPECIAL FABRICATION TECHNIQUES. Reactor Mater., 12: 60-71(Spring 1969).

Research results on cast and wrought reactor materials are summarized. Information on development of powder metallurgy methods, pressure bonding, metal plating, and brazing and welding is given. Research on nondestructive testing is reported. 51 references are included. (F.S.)

**20495** FUEL ELEMENT FOR NEUTRONIC REACTOR AND METHOD OF FABRICATION THEREOF. Williams, L. C. (to United States Atomic Energy Commission). U. S. Patent 3,441,478. Apr. 29, 1969.

An integral fuel pin and grid structure for a pin-type reactor fuel element is described. Substantially cylindrical fuel pins are deformed into a rectangular cross section along a short segment of the pins adjacent to but spaced apart from one end. The fuel pins are positioned in a row in an abutting relationship along the smaller faces of their deformed rectangular segments, with a

connector pin extending along the length of the row through apertures in the abutting faces. The fuel pins are then brazed to one another along the abutting faces to form a row of integrally connected fuel pins. A plurality of rows of fuel pins arranged in a side-by-side relationship form a fuel element. Where a vented fuel element is desired, the connector pin in each row of fuel pins may be tubular in form and provided with radial apertures so that fuel pin fluid intercommunication is provided. At least one fuel pin in each row of fuel pins is then vented to an external gas collection system. (AEC)

**20496** COMPOSITE GREEN STRUCTURES FOR NUCLEAR FUEL ELEMENT. Johnson, James R.; Sowman, Harold G. (to Minnesota Mining and Mfg. Co.). U. S. Patent 3,436,307. Apr. 1, 1969. Filed Sept. 22, 1966.

Green structures adapted to be fired to form metallic nuclear fuel elements, comprising laminates of sheets of powdered metal, an organic binder, sheets of powdered metal with fissionable fuel distributed throughout, and a plastic binder are described. The fuel-containing sheets are covered with the plastic metallic sheets and bonded to form a unitary green structure under conditions in which the sheets remain isotropic. The green structures are adapted to firing which converts them to sintered metallic fuel elements in which the fissionable fuel is distributed inside a unitary metallic sheet in a predetermined location. After firing, the metallic portion has uniform grain structure and boundaries of the original sheets cannot be distinguished. (Offic. Gaz.)

## Properties Evaluations

*Refer also to abstracts 20474, 20477, 20480, 20536, and 21568.*

**20497** (BARC-368) DIFFUSION OF RARE EARTH ELEMENTS IN ALUMINUM. Murarka, S. P.; Agarwala, R. P. (Bhabha Atomic Research Centre, Bombay (India)). 1968. 30p. Dep.

Tracer diffusion of lanthanum, cerium, praseodymium, neodymium, and samarium in aluminum was studied using a residual activity technique. Diffusion coefficients (in $cm^2/sec$) can be expressed as: $D_{La/Al} = 1.40 \times 10^{-6} \exp(-27{,}000/RT)$, $D_{Ce/Al} = 1.90 \times 10^{-6} \exp(-26{,}600/RT)$, $D_{Pr/Al} = 3.58 \times 10^{-7} \exp(-23{,}870/RT)$, $D_{Nd/Al} = 4.80 \times 10^{-7} \exp(-25{,}000/RT)$, and $D_{Sm/Al} = 3.45 \times 10^{-7} \exp(-22{,}880\ RT)$. Experimental results are discussed on the basis of the low solid solubility of the tracers. Data on impurity diffusion in aluminum were examined on the basis of theories of charge and size difference between the impurity and aluminum atoms. Theories based on the vacancy impurity interaction and the size effect were found applicable to almost all the solutes in trivalent aluminum within the limits of accuracy of the experiment. (auth)

**20498** (GA-1701) A PROGRAM OF RESEARCH ON MECHANICAL METALLURGY AS RELATED TO FUEL-ELEMENT FABRICATION. Quarterly Progress Report for the Period Ending June 30, 1960. Chambers, R. H.; Trozera, T. A.; White, J. L. (Gulf General Atomic, Inc., San Diego, Calif.). Sept. 12, 1960. Contract AT(04-3)-167. 24p. Dep. CFSTI.

Data obtained in tensile tests of type 1100 Al, and in measurements of stored energy of cold working using differential calorimeters are reported. Tables show results of calibration experiments on the heats of fusion of Pb and Sn and show comparative values obtained previously. Also reported are measurements of the stored-energy release in OFHC copper deformed in tension, of Al deformed in compression, and the results of an experiment on reactor-grade Nb deformed in compression at 0°C. (P.G.C.)

**20499** (ORNL-4350, pp 242-8) NONDESTRUCTIVE TEST DEVELOPMENT. (Oak Ridge National Lab., Tenn.).

Existing ORNL computer programs were modified to plot contours of the defect sensitivity factor for various configurations of eddy-current coil and conductor. A diagram illustrates how sensitivity to defects varies with position in a conductor for a coil above a conducting plate. Probes of high-temperature reflection coils were fabricated for use with phase-sensitive eddy-current instruments. The recently constructed mirror schlieren system was evaluated for sensitivity, stability, and ease of operation. Plans were developed for applying the schlieren system to ultrasonic inspection of welds. A frequency-analysis system was applied to investigate the energy patterns radiated from various types of ultrasonic transducers. (P.G.C.)

**20500** (ORNL-4350, pp 293-310) PHYSICAL AND MECHANICAL METALLURGY OF REFRACTORY ALLOYS. (Oak Ridge National Lab., Tenn.).

Results of measurements at 1600 and 1800°C on the solubility, diffusivity, and permeability of N in W are tabulated and compared with those previously reported in the literature. The age hardening characteristics of Nb-Hf and Ta-Hf alloys were studied. It was found that the rate of precipitation as well as the morphology of Nb-Hf alloys was extremely sensitive to the rate of quenching, and preliminary tensile tests indicated that yield strength varied with different heat treatments. A general equation for the free energy of mixing in spinodal alloys was developed, based on thermodynamic and statistical calculations. In connection with the development of high-temperature brazing alloys for joining refractory metals, ceramics, and graphite to themselves and to each other the mechanical properties of alloys proven acceptable in wetting and flowing experiments were determined. Tests at ambient and elevated temperatures were completed on Ta-W 10% and TZM alloys. The effect of prolonged exposures at high temperatures on the shear strength of Ta-10% W was determined. It was found that brazes made with alloys from the Ti-Zr systems did not weaken noticeably during aging although alloys in the Ti-V systems had lower shear strength after aging. Data on thermal conductivity and electrical resistivity of W and W-base-Re alloys were used for testing of complex estimation methods for predicting the thermal conductivity of the materials from 80 to 1700°K. A table indicates the methods used and their limitations. (auth)

**20501** (ORO-3401-10) RESIDUAL STRESS MEASUREMENTS ON THIN ELECTRODEPOSITED FILMS. Feaster, R. V.; Block, Robert Jay (Oklahoma Univ. Research Inst., Norman). Feb. 1969. Contract AT(40-1)-3401. 48p. Dep. CFSTI.

The residual stress in thin films of Cr, Rh, Re, Au, and Ru, electrodeposited on polycrystalline substrates, was investigated. The morphology of the deposits on single crystal and polycrystalline substrates was determined using x-ray and electron diffraction techniques. Results indicate that simple lattice mismatch between coating and substrate was not by itself an adequate criteria from which coating stress could be predicted. Calculations of residual stresses based on Van der Merwe's equation predicted only relative stress levels. It was found that x-ray line broadening by itself could not be used for accurate measurements of residual stress. However, shifts of the x-ray diffraction peaks were always associated with substantial levels of stress. (auth)

**20502** SURFACE POTENTIAL OF NITROGEN ON URANIUM AND ON THORIUM. Riviere, J. C. (Atomic Energy Research Establishment, Harwell, Eng.). Soc. Chem. Ind. (London), Monogr., No. 28, 188-98(1968).

From Conference on Surface Phenomena of Metals, London, Eng. See CONF-670978-3.

Nitrogen was admitted at a slow rate to films of uranium and of thorium deposited on tungsten foil in ultra-high vacuum. The changes in work function of the films during adsorption of the nitrogen were monitored by continuous measurement of the contact potential difference between their surfaces and that of a vacuum-deposited film of silver, which does not chemisorb nitrogen at room temperature. In both cases initial adsorption produced a positive surface potential that rose to a maximum of 0.210 eV for uranium and 0.267 eV for thorium. There were also subsidiary maxima at low coverage, three at 0.043, 0.051, and 0.145 eV in the case of uranium, and one at 0.135 eV in the case of thorium. These latter features are interpreted as being due to completion of an "effective" monolayer, or to the appearance of a new phase at the surface. Continued adsorption on uranium caused a sudden drop in the surface potential just after the maximum positive value was reached, to a value, 0.046 eV, that did not change further even after saturation with nitrogen at 35 torr. On the other hand, continued adsorption on thorium after the maximum positive value produced a slow decrease in the surface potential until it eventually passed through zero and became negative, reaching an apparently constant value of −0.260 eV. Increasing the rate of admission of nitrogen at that point, however, caused a very rapid increase to −0.690 eV, followed by a reversal to −0.556 eV, and a much slower increase to a final maximum of −1.167 eV. Saturation with nitrogen at 10 torr did not affect the surface potential further. The observation of a positive surface potential at low coverages is interpreted, as it was for oxygen adsorption, in terms of penetration of nitrogen into the surface. At higher exposures to nitrogen, the observed rapid changes in the rate of change of the surface potential with time that occurred for both uranium and thorium, are associated with the formation of higher nitrides at the surface. On the basis of the differences in stoichiometric behavior between $U_2N_3$ and $Th_3N_4$, the results at saturation pressures are interpreted as meaning that the uranium reaction goes to completion at once, but that the reaction of nitrogen with thorium is very slow, and was not complete during the time of the experiment. (auth) (UK)

**20503** PROPERTIES AND USES OF TITANIUM ALLOYS. Knorr, W. (Fried. Krupp GmbH Schmiede und Giesserei, Essen).

Tech. Mitt. Krupp, Werksber., 27: 25-37(Feb. 1969). (In German).

The properties and uses of the most common industrial Ti alloys are outlined. The effects of various alloying components, structure and heat treatment on the room-temperature and elevated-temperature properties of the alloys as determined by short- and long-time tests are discussed. Reference is made to the future development of high-strength through-hardening alloys of high toughness for medium to large-size forgings and for sheet material of adequate formability. Examples are given of the uses currently made of these alloys in the aerospace industry, in the automotive and mechanical engineering industries and in the field of precision mechanics. (auth)

**20504** FATIGUE-CRACK GROWTH-RATE STUDIES OF LOW-ALLOY PRESSURE-VESSEL STEELS. Mowbray, D. F.; Andrews, W. R.; Brothers, A. J. (General Electric Co., Schenectady, N. Y.). J. Eng. Ind., 90: 648-55(Nov. 1968).

Fatigue-crack growth rates were determined at room temperature for ASTM A302-Class B and A508-Class 2 steels in two characteristic plate and forging directions. Tests were performed under zero-to-tension cyclic loading using both through-crack and part-through-crack plate specimens. Crack growth rates in the through-crack specimens, though affected by plate or forging directions, were found to correlate well upon the hypothesis that the crack extension per cycle is proportional to a positive power of the range of alternating stress intensity factor. In addition, the rate of crack extension through the plate thickness of the surface-crack specimens was successfully correlated with data from through-crack specimens. (auth)

**20505** INFLUENCE OF WELD DEFECTS ON PERFORMANCE. Lindh, D. V.; Peshak, G. M. (Boeing Co., Renton, Wash.). Weld. J. (N. Y.), 48: 45s-56s(Feb. 1969).

An experimental program was undertaken to develop a semi-empirical method of predicting the effect of weld defects on the static and fatigue properties of weldments. The results show that Ti-6Al-4V weldments suffer no significant decrease in static properties. Fatigue properties of Ti-6Al-4V weldments were found to be reduced by defects too small to be detected by present nondestructive testing methods; however, the reduced fatigue properties were still better than are reported for most mechanical joints. (auth)

**20506** TITANIUM: ITS PROPERTIES AND USES IN THE CHEMICAL INDUSTRY. Knorr, W. (Fried. Krupp GmbH Schmiede und Giesserei, Essen). Tech. Mitt. Krupp, Werksber., 27: 5-17(Feb. 1969). (In German).

A general survey of the corrosion behavior of titanium is given and some critical cases of corrosion resistance are described. Reference is also made to cases of stress and crevice corrosion known to have been encountered in practice. Other subjects discussed are the mechanical properties of unalloyed titanium grades, their long-time creep behavior, the established calculation values, and the temperature limits for the application of titanium. Various examples are cited to show the wide range of uses to which titanium is being put in chemical engineering to manufacture process equipment of solid titanium or lined construction. For elevated-temperature or high-stress applications, titanium alloys or composite materials made of titanium and steel are recommended. The manufacture and characteristics of explosion-clad plates as well as the processing and welding of this new type of material are described. (auth)

**20507** THE INFLUENCE OF SMALL ALLOY ADDITIONS ON THE STRUCTURE OF CAST PURE ALUMINUM. Grebe, W.; Grimm, H.-P. (Technische Hochschule, Munich). Aluminium, 43: 673-9(Nov. 1967). (In German).

A study of the effects of small alloy additions on the grain size of cast Al is reported. Grain refinement is produced by Zr, Nb, V, Ti, Ta, and Hf, in order of increasing effectiveness, even in the absence of C or B. Hf, Ta, Ti, and V, which form compounds with Al of the $DO_{22}$ type, produce very marked effects in the peritectic alloys. In pure binary systems a grain-refining effect might be predicted in the cases of Hf, Ta, Ti, and V from consideration of the phase diagram and compound formation. A relation between the formation of sub-grain segregated structure, the supercooling characteristics, and the grain size seems possible. (R.C.K.)

**20508** PRECIOUS STEELS IN NUCLEAR TECHNOLOGY. Rajakovics, G. E. Nukl. Energ., 5: No. 2, 7-13(1968). (In Serbo-Croatian).

Requirements for steels used in nuclear technology with regard to special physical properties, safety requirements, and plant size are analyzed. Improvements in the qualities of known steels and development of new steels are reported. These steels contain limited quantities of alloying elements unfavorable from the standpoint of nuclear physics. (J.G.B.)

**20509** CRACK PROPAGATION IN HYDRIDED ZIRCALOY-2. Oestberg, G. (Aktiebolaget Atomenergi, Stockholm). Int. J. Fracture Mech., 4: 95-9(June 1968).

Increasing the amount of hydrogen or hydride in Zircaloy-2, which is used for nuclear fuel element cladding, leads to a decrease of the ductility which normally becomes drastic at a certain hydrogen content. An explanation was sought for the drop in ductility with increasing hydrogen content at room temperature where the hydride is less ductile than the Zr matrix. Transmission electron microscope observations of cracks in thin foils of Zircaloy-2 containing hydride particles showed that the fracture process is one of linking-up satellite cracks in the hydride phase in front of the tip of the main crack. The semi-quantitative observation of the width of the zone of high stress and strain in front of a crack was made on a partly cracked tube of hydrided Zircaloy-2. The surface in the region of interest was covered with a photoelastic plastic film (Budd type L11) for observation of the stress and strain distribution under polarized light. When the tube was stressed so that a crack was opened up slightly, the shape of the zone of high stress and strain was what might be expected from normal fracture mechanics concepts. Furthermore, its width was found to correspond to the area where the hydride platelets were cracked. The observations corroborate the idea that the drop in ductility occurs when the distance between the hydride particles equals the range of stress and strain which is critical for cracking of the hydride in front of the advancing crack. (BBB)

**20510** SELF-DIFFUSION OF INDIUM IN MOLTEN InSb COMPOUND. Petrescu, N.; Zamirca, St.; Ganovici, Lucia; Ganovici, I. (Physical Chemistry Research Centre, Bucharest). Rev. Roum. Chim., 13: 865-77(July 1968).

The self-diffusion of indium in the molten InSb compound was studied by the capillary-reservoir using $^{114}In$ as a tracer. The method, which permits the diffusion runs being carried out in a continuous manner, is described and several measuring techniques used for determination of the diffusion coefficients are discussed. The results can be represented by the equation: $D = 3.02 \times 10^{-4} \exp(-2.903/RT)$. Relations were made between the diffusion data and a series of structural data on the molten and solid compounds, by making use of an expression for the pre-exponential factor, the correlation of viscosity with diffusivity, on Swalin's expression for the temperature dependence of the diffusion coefficient. (auth)

**20511** ELECTROCHEMICAL BEHAVIOR OF MOLYBDENUM. Wikstrom, L. L.; Nobe, Ken (Univ. of California, Los Angeles). J. Electrochem. Soc., 116: 525-30(Apr. 1969).

The anodic and cathodic polarization of molybdenum in 1N $H_2SO_4$ was investigated. In deaerated solutions, two stable rest potentials, 0.368 and −0.020 V vs. normal hydrogen electrode (NHE), were observed, depending on the activation procedure. In aerated solutions, only the rest potential of 0.368 V was observed. From the more noble rest potential, an anodic Tafel slope of 44 ± 4 mV and a corrosion current of 1.5 ± 0.8 $\mu A/cm^2$ were obtained. For the hydrogen electrode reaction (h.e.r.), a Tafel slope of 70 ± 3 mV and an exchange current of 0.10 ± 0.04 $\mu A/cm^2$ were obtained. Two distinct active-passive transitions were observed between the two rest potentials. The short-time galvanostatic transients exhibited two linear regions in the potential-time responses and could be represented by an electrical model of two R-C networks in series. Capacitance values were determined from the slopes of the two linear regions. The first capacitance was attributed to $MoO_2$ at the $Mo-MoO_2$ interface and was a constant value of 3.75 $\mu F/cm^2$ throughout the potential region investigated. The second capacitance was surmised to be a pseudocapacitance and ranged from 200 to 600 $\mu F/cm^2$. However, for sufficiently large polarization from the more noble rest potential, the second capacitance was too large to be measured. (auth)

## *Structure and Phase Studies*

*Refer also to abstracts 20472 and 20480.*

**20512** (CEA-R-3526) CONTRIBUTION TO THE STUDY OF POINT DEFECTS IN URANIUM $\alpha$. Jousset, Jean-Claude (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires). Dec. 1968. 104p. (In French). Dep.

Thesis. Submitted to Univ. of Paris, Orsay, France.

Uranium quenched from temperatures as low as 100°K shows an increase in resistivity which disappears after annealing between 4.2 and 41°K. This phenomenon is explained by cold-working

of the metal due to the rapid traversing of the temperature region where the lattice parameters exhibit an important and anisotropic increase. The annealing occurs in stages at 4.2 to 26°K and at 26 to 42°K. Purity of samples has an influence on the phenomenon. Model proposed is confirmed by the comparison with experiments of annealing of defects created by irradiation of uranium at very low temperatures. Vacancies have been quenched in the metal from temperatures around 650°C (limit of the $\alpha$ phase). The formation energy so found is $E_F = 0.5 \pm 0.15$ eV. The annealing out of the induced resistivity happens in two stages (300 to 390°C; 420 to 560°C). (auth)

**20513** DIFFUSION OF CARBON IN VANADIUM. Son, Pongun (Osaka Univ.); Ihara, Seiichi; Miyake, Masanobu; Sano, Tadao. Nippon Kinzoku Gakkaishi, 33: 1-3(1969). (In Japanese).

The diffusion coefficients of carbon in vanadium were studied by a tracer technique using $^{14}C$ at 845 to 1130°C. The diffusion coefficients are described by an equation, $D = D_0 \exp(-E/RT)$ ($cm^2/sec$) where $D_0$ and E are 0.0049 $cm^2/sec$ and 27.3 kcal/mol, respectively. These values coincide very well with those obtained by Powers et al., using the elastic after effect. (auth)

**20514** ELECTRON MICROSCOPIC OBSERVATION OF CRACK PROPAGATION IN W THIN FOIL. Saito, Yoshihiro; Nenno, Soji (Osaka Univ.). Nippon Kinzoku Gakkaishi, 32: 1266-9(1968). (In Japanese).

Cleavage cracks were introduced into W thin foils at room temperature. The crystallography of crack propagation was studied and dislocations near cracks were examined by transmission electron microscopy. Trans-crystalline and intergranular cracks were observed. The trans-crystalline cracks propagated mainly in the {110} type plane. The cracks in the {110} type plane were smooth, but cracks in nonprincipal planes were not smooth. There were observed many cracks whose tips were high in dislocation density. Slip traces were observed near cracks. (auth)

**20515** FIELD-ION MICROSCOPE STUDIES OF PLANAR FAULTS. Ranganathan, S. (Univ. of California, Berkeley). pp 120-36 of Field-Ion Microscopy. Hren, John J.; Ranganathan, S. (eds.). New York, Plenum Press, 1968.

The geometry of the stacking falut and its probable contrast in field ion micrographs are discussed. Stacking-fault geometry in fcc and bcc structures is described. Streak contrast interpreted as stack faults and the crossover effect in W interpreted as stacking faults on (111) plane are considered. The streak contrast effect is also interpreted as arising from nodes in a dislocation network. Stacking faults in the hexagonal close packed (hcp) structure and domain boundaries in ordered alloys are discussed. (F.S.)

## Radiation Effects

*Refer also to abstracts 20534 and 21451.*

**20516** (BMI-1857, Sect.B) RADIATION EFFECTS ON FAST-REACTOR CLADDING AND STRUCTURAL MATERIALS. (Battelle Memorial Inst., Columbus, Ohio). 17p.

Progress is reported in a program to determine the effects of radiation on various reactor cladding and structural materials and to characterize the embrittlement observed in cladding materials for liquid metal fast breeder reactors (LMFBR). Progress is reported in studies on radiation effects on mechanical properties of 304 and 316 stainless steel and microstructural aspects of embrittlement. New techniques developed to relieve requirements for extensive specimen preparation in studies of radioinduced mechanical property changes are described. The effects of irradiation temperature, dose rate, and flux spectrum on radiation damage were studied. (F.S.)

**20517** (NRL-6772) INITIAL ASSESSMENTS OF NOTCH DUCTILITY BEHAVIOR OF A533 PRESSURE VESSEL STEEL WITH NEUTRON IRRADIATION. Hawthorne, J. Russell; Potapovs, Uldis (Naval Research Lab., Washington, D. C.). July 12, 1968. Contract AT(49-5)-2110. 20p. Dep. CFSTI.

Assessments were made of the Charpy-V notch ductility characteristics of heavy section A533-B and A533-C steel plate and submerged arc weldments following neutron irradiation at 550°F. Major research findings include the observation of significant variability in radiation embrittlement sensitivity of A533-B and A533-C steel. Results of the study show that the radiation embrittlement resistance of commercially produced A533 steel plate and weld deposits can be predicted in part from their individual chemical compositions. High copper and phosphorus contents generally signify high sensitivity to 550°F radiation-induced changes in notch ductility characteristics. (auth)

**20518** (ORNL-4334) RADIATION METALLURGY SECTION, SOLID STATE DIVISION PROGRESS REPORT FOR PERIOD ENDING JULY 1968. (Oak Ridge National Lab., Tenn.). Feb. 1969. Contract W-7405-eng-26. 73p. Dep. CFSTI.

The results of research and development are reported in six sections. A separate abstract was prepared for each section. (J.R.D.)

*For abstracts of individual sections see: 20479 and 20519-20523.*

**20519** (ORNL-4334, pp 9-20) EFFECT OF INTERSTITIAL IMPURITIES ON POSTIRRADIATION ANNEALING PHENOMENA IN NIOBIUM. Williams, J. M.; Stanley, J. T.; Brundage, W. E. (Oak Ridge National Lab., Tenn.).

Results of annealing at 50 to 550°C are reported. Impurity levels, analyzed by chemical and physical methods, are reported along with measurements of internal friction and electric conductivity. Discussions are included concerning the reasons for electric conductivity and internal friction variations. (J.R.D.)

**20520** (ORNL-4334, pp 21-9) PSEUDO SNOEK PEAK IN NIOBIUM. Stanley, J. T. (Oak Ridge National Lab., Tenn.).

An investigation of the anomalous behavior of the oxygen Snoek peak which developed in irradiated and annealed Nb during internal friction and electric resistivity measurements is described. Evidence is presented to show the Snoek peak pseudo. (P.G.C.)

**20521** (ORNL-4334, pp 29-33) RADIATION ANNEAL HARDENING IN NIOBIUM. Ohr, S. M.; Tucker, R. P. (Oak Ridge National Lab., Tenn.).

The mechanism of radiation anneal hardening in Nb is discussed in terms of dispersed barrier interactions between trapped interstitial impurity atoms and moving dislocations. Defect clusters identified as dislocation loops at a density of $6.1 \times 10^{15}/cm^3$ with an average diameter of 93 Å were observed by transmission electron microscopy in Nb after neutron irradiation. It is postulated that trapped C atoms migrate to radiation-induced defects during annealing and are trapped. The trapped C atoms strengthen the defects as barriers to dislocation motion causing an increase in yield strength. (P.G.C.)

**20522** (ORNL-4334, pp 33-63) DISLOCATION CHANNELING IN NEUTRON-IRRADIATED NIOBIUM. Tucker, R. P.; Wechsler, M. S. (Oak Ridge National Lab., Tenn.).

Transmission electron micrography was used in a study of the features of dislocation channeling in irradiated-and-plastically deformed Nb. Electron beam melted monocrystalline Nb was cold rolled into 0.13 mm thick sheet, annealed at 1050°C in vacuum, irradiated at a neutron flux of 1.8 and $4.4 \times 10^{13}$ neutrons $cm^{-2}/sec^{-1}$ (>1 MeV), and deformed under tension at room temperature. The average grain size in the specimens was 44 $\mu$ and exhibited a preferred grain orientation with [111] nearly perpendicular to the surface. A measure of the direction and magnitude of shear displacement produced by channeling dislocations was determined by observation of the offset where microstructural features were crossed by dislocation channels. It is postulated that surface slip lines correspond to dislocation channels and that strain is heavily concentrated in the channels. It was observed that there generally appeared to be no defect clusters within cleared channels when the channel plane was perpendicular to the plane of view. The precise mechanisms involved in the removal of defect clusters is a matter of conjecture. A possibility considered is that the motion of channeling dislocation produces an input of energy, largely converted to heat, which may anneal the damage clusters caused by radiation. It is also possible that defect clusters are removed during the motion of channeling dislocation by the production of antidefects. It is considered that the phenomenon of dislocation channeling plays a central role in the plastic deformation of irradiated metals. (P.G.C.)

**20523** (ORNL-4334, pp 63-7) TEMPERATURE DEPENDENCE OF RADIATION HARDENING. Ohr, S. M. (Oak Ridge National Lab., Tenn.).

As part of a study to explain the temperature dependence of radiation hardening in metals equations were developed to show the critical temperatures above which thermal activation alone is sufficient to move dislocations past dislocation loops. (P.G.C.)

**20524** (ORNL-4344, pp 211-90) MATERIALS DEVELOPMENT. McCoy, H. E.; Weir, J. R. Jr. (Oak Ridge National Lab., Tenn.).

Research results are presented on MSRE surveillance program, graphite studies, Hastelloy N evaluation and optimization, and graphite-to-metal joining. Support activities for the components development program are summarized. (J.R.D.)

**20525** (ORNL-4350, pp 148-73) MECHANICAL PROPERTIES RESEARCH AND LMFBR CLADDING AND STRUCTURAL MATERIALS DEVELOPMENT. (Oak Ridge National Lab., Tenn.).

Continued evaluation of the mechanical properties of neutron irradiated cladding materials for LMFBR such as Ti modified Hastelloy N, and types 316, 316L, and 304 stainless steels is reported. Studies were made of the effect of aging on the tensile properties of Ti-modified Hastelloy N, and the effects of irradiation temperature. Results of electron microscopy indicate that the types and behavior of precipitated phases in unmodified Hastelloy N are closely related to the concentration of Si, but that the microstructure of the modified alloy is different from that of the standard alloy. The effects of variations of Ti and C content on the tensile properties of unirradiated Incoloy 800 were measured and the relations between grain size and creep rate of irradiated Incoloy 800 were determined. (P.G.C.)

**20526** (ORNL-4350, pp 174-225) RADIATION EFFECTS IN ALLOYS AND STRUCTURAL MATERIALS. (Oak Ridge National Lab., Tenn.).

The causes of radiation embrittlement of metals and structural alloys including iron and reactor pressure-vessel steels were investigated. The effect of strain rate on yield and fracture of type A 212-B steel is under current investigation. To measure the load and energy absorbed by a Charpy notch-impact machine, strain sensors have been added for studying the relations between radiation hardening and embrittlement. Tensile properties, determined for both irradiated and unirradiated type A 523-B steel plate are tabulated. The dependence of mechanical properties on temperature and fluence have been determined for irradiated Ferrovac E iron, as has the effect of interstitial solutes. Studies were begun to determine the influence of interactions of interstitial impurities on radiation induced defects in V. (P.G.C.)

**20527** INVESTIGATION OF THE IMPACT PROPERTIES OF IRRADIATED BERYLLIUM. Hesse, J. L.; Beeston, J. M.; Ford, C. Q. (New Mexico State Univ., University Park). J. Nucl. Ene rgy, 23: 39-47(Mar. 1969).

Impact tests were conducted on four unirradiated Be specimens, and on fourteen Be specimens irradiated in the range $1.75 \times 10^{21}$ n/cm$^2$ to $3.86 \times 10^{21}$ n/cm$^2$, using apparatus designed to deliver repetitive axial compressive blows of 4.16 or 8.93 kg.m energy content per blow. Izod tests were performed on 7 unirradiated specimens, and on 19 specimens irradiated in the range $1.75 \times 10^{21}$ n/cm$^2$ to $4.39 \times 10^{21}$ n/cm$^2$, with three additional samples irradiated in the range $2.36 \times 10^{21}$ n/cm$^2$ to $2.65 \times 10^{21}$ n/cm$^2$ subjected to a 2 hr-600°C anneal prior to testing. Relationships are given for compressive and Izod failure energies as functions of fluence, and for the ratio of these energies as a function of fluence. Representative fractographs are shown for each irradiated material category, and scanning electron micrographs are presented for the unirradiated compressive impact samples. A prediction is made of critical fluence at which Be loses essentially all of its resistance to impact. (auth) (UK)

**20528** INFLUENCE OF FAST NEUTRONS AND MACROSONICS ON METAL STRUCTURE. Langenecker, B. (Laboratorium fuer Angewandte Physik, Wenigzell, Austria). Acta Phys. Austr., 27: 154-60(1968). (In German).

The effect of ultrasonic waves of high amplitude (macrosonics in the 20 and 40 kHz range) and fast neutrons (>0.1 MeV; $\sim 2 \times 10^{16}$ n/cm$^2$) on Al single crystals is expressed in a modification of the physical properties such as yield point, plasticity, and electric conductivity. It was shown that the superposed energy irradiation increases the nonlinear interaction of (macrosonic)-field and material and therefore gives a deeper insight into the mechanism of the activation of various processes in the lattice. A refined method, which permits the pattern of these mechanisms to be continuously observed and to resolve the individual activation processes, was reported and its efficiency was described on the basis of some observation results. (tr-auth)

**20529** FIELD-ION MICROSCOPE STUDIES OF RADIATION DAMAGE. Ralph, B. (Univ. of Cambridge, Eng.). pp 171-82 of Field-Ion Microscopy. Hren, John J.; Ranganathan, S. (eds.). New York, Plenum Press, 1968.

Field ion microscope studies of neutron damage and other radiation damage experiments in which the specimen is prepared in field ion form prior to irradiation are discussed. Experiments are time consuming and involve considerable interpretation. However, the field ion microscope is uniquely suited to damage studies. It is being applied by an increasing number of researchers. (F.S.)

## Ceramics and Cermets

*Refer also to abstracts 19744, 20463–20465.*

**20530** (BMI-1857, Sect.A) URANIUM-PLUTONIUM NITRIDE FUELS FOR LMFBR APPLICATIONS. (Battelle Memorial Inst., Columbus, Ohio). 42p.

Progress is reported on studies devoted to sintering UN-PuN fuels; vaporization of PuN and UN-PuN alloys; nitride diffusion; UN-PuN compatibility with cladding and coolant materials; sodium wetting of nitride fuels and cladding materials; fabrication, cladding, irradiation, and evaluation of nitride fuels, and nitride pellet fuels for the EBR-II. (F.S.)

**20531** MODERATOR AND CONTROL MATERIALS. Reactor Mater., 12: 16-24(Spring 1969).

Research and development progress summaries on graphite, beryllium, beryllium alloys, solid hydrides, metallic poison materials, and dispersion and nonmetallic poison materials are presented. 33 references are included. (F.S.)

### Preparation and Fabrication

*Refer also to abstracts 19718, 19817, 20490, 20494, and 20557.*

**20532** (CONF-680610-, pp 51-62) USE OF CHEMICAL VAPOR DEPOSITION TO CONVERT HALIDES TO FISSIONABLE FUEL COMPOUNDS. Robinson, W. C. Jr.; Federer, J. I.; Martin, W. R. (Oak Ridge National Lab., Tenn.).

Studies on chemical vapor deposition techniques by ORNL for preparation of ceramic nuclear fuels are reviewed. These include making $UO_2$ powder from $UF_6$ in a flame reactor and demonstration of conversion of $UF_6$ to UN and UC with lithium and appropriate gases, uranium chlorides to $UO_2$, and $PuF_6$ to $PuO_2$. (auth)

**20533** (KFK-787) DEPOSITION OF CHROMIUM ON $UO_2$- AND $Al_2O_3$-SPHERES FROM THE GAS PHASE. Schneider, H.; Schoenwald, D. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Material- und Festkoerperforschung). July 1968. 20p. (In German). (EUR-3959). Dep.

A method for the preparation of chromium carbide or chromium coatings on $UO_2$ or $Al_2O_3$ spheres in a fluidized bed is described. During thermal decomposition of chromium dicumene in the presence of a catalyst, coatings of chromium carbide ($Cr_7C_3$) with about 10% C were obtained, in which the evaporated chromium carbide mixtures on charges of 50 g of $Al_2O_3$ spheres amounted to 20 vol. %. In the presence of iodine as catalyst, the chromium coatings obtained through the thermal decomposition of chromium dicumeme contained a maximum of 0.05% C. Up to 34 vol. % of the chromium was transported to charges of 50 g of $UO_2$ spheres. The coatings obtained by both methods were of very good quality, of metallic luster, dense, and homogeneous. X-ray and chemical analysis detected no impurities. The coated particles were used for the preparation of $UO_2$–Cr cermets with idealized structure. (tr-auth)

**20534** (ORNL-4350) FUELS AND MATERIALS DEVELOPMENT PROGRAM. Quarterly Progress Report for Period Ending September 30, 1968. Patriarca, P.; Harms, W. O. (comps.) (Oak Ridge National Lab., Tenn.). Feb. 1969. Contract W-7405-eng-26. 320p. Dep. CFSTI.

The report is divided into fourteen sections. A separate abstract was prepared for each section. (J.R.D.)

*For abstracts of individual sections see: 20469, 20480–20482, 20499, 20500, 20525, 20526, 20535–20537, and 20557–20559.*

**20535** (ORNL-4350, pp 3-32) SOL-GEL FAST REACTOR FUELS. (Oak Ridge National Lab., Tenn.).

The program to obtain technical data needed to assess the potential of sol-gel-derived $(U,Pu)O_2$ fuel for liquid-metal cooled fast breeder reactors and to provide basic technology for the development of commercial fabrication plants is described. The primary requirement is to establish an economical fabrication procedure that will produce fuel rods meeting the criteria for reliable and safe operation in a fast breeder reactor. To meet this requirement, Sphere-Pac, pelletized, and extruded fuels were fabricated, characterized, and irradiated in capsules in thermal and fast reactors to determine their operating limits. (auth)

**20536** (ORNL-4350, pp 33-66) NITRIDE FUELS DEVELOPMENT. (Oak Ridge National Lab., Tenn.).

Studies on the development of mixed U–Pu nitrides and carbonitrides for liquid-metal-fast-breeder reactors continued as did research to determine the ultimate limitations of UN as a nuclear space fuel. Problems associated with the use of mixed nitrides or carbonitrides for LMFBR fuels involve economical synthesis and fabrication, compatibility with cladding alloys, including effects of fuel burnup, model studies on carbide and nitride fuel pins, and

irradiation behavior. A high priority is placed on development of quantitative descriptions of thermodynamic properties and reaction kinetics, in the materials systems investigated, for application to fabrication schemes and solution of compatibility problems. Irradiations of promising combinations of fuels and cladding are conducted under simulated service conditions. (auth)

**20537** (ORNL–4350, pp 260–89) FUEL ELEMENT FABRICATION DEVELOPMENT. (Oak Ridge National Lab., Tenn.).

Sample and instrumented Al-base irradiation-test fuel plates were fabricated for the G-12 loop experiment and ultrasonically tested for non-bond by through-transmission techniques. Compositions of the plates, properties, and results of ultrasonic inspection are tabulated. Methods and equipment used to prepare $UAl_x$ fuel powders are described. Sol-gel $U_3O_8$ produced for HFIR was characterized. Anodic film coatings for cladding Al fuel elements were developed and tested. The program to establish the feasibility of converting $PuF_6$ to $PuO_2$ in a one-step process by CVD techniques continued and was extended to include the simultaneous conversion of $PuF_6$–$UF_6$ mixtures to the mixed oxide. Results of experiments to produce $UF_4$ in an oxygen-starved system and $UOF_2$ in a hydrogen-starved system are reported. The thermal conductivity of $UO_2$–W pellets prepared in the flame-reactor from gas mixtures containing $UF_6$, $WF_6$, $H_2$, and $O_2$ was determined. A study was conducted to determine the effect of deposition parameters on the characteristics of SiC produced by CVD techniques from silicon tetrachloride-methane-hydrogen mixtures. Composition and surfaces varied markedly as a function of the operating parameters. Studies on nondestructive inspection techniques of fuel plates continued. (P.G.C.)

**20538** IMPROVEMENTS IN OR RELATING TO THE MANUFACTURE OF NUCLEAR FUEL. Horsley, Geoffrey Winton (to United Kingdom Atomic Energy Authority). British Patent 1,146,015. Mar. 19, 1969. Filed Mar. 11, 1966.

The process described relates to the production of pyrolytic carbon coated oxide fuel particles. It is stated that the coating process commonly used, when applied to porous oxide particles, may result in partial transformation of oxide to carbide and also a serious loss of fuel material due to the formation of volatile compounds with the carbon in the hydrocarbon gas used in the coating process; this loss can amount to as much as 18% for porus $PuO_2$ particles. The described process includes the introduction of CO gas into the coating gas. An example is described for the preparation of hard spheroids consisting of a dispersion of $Pu_2O_3$ and $PuO_2$ in carbon, surrounded by an impervious layer of pyrolytic carbon, by a fluidization process. (UK)

**20539** HIGH LOADED $UO_2$–COLUMBIUM CERMETS. Fuhrman, N.; Gordon, E.; Holden, R. B. (to United States Atomic Energy Commission). U. S. Patent 3,429,699. Feb. 25, 1969.

A process described for producing improved $UO_2$–Nb cermets, having ceramic phase loadings of over 70 vol %, comprises coating $UO_2$ spheres with a wax coating, then with a mixture of powdered Nb and carbon, forming a compact, dewaxing the compact, and heat sintering the compact, wherein the carbon removes oxygen impurities and increases the theoretical density of the cermet. (AEC)

**20540** PROCESS FOR THE PREPARATION OF NUCLEAR FUELS CONTAINING MIXED CARBIDES. Beucherie, Pierre; Wurm, Joseph Gerard (to EURATOM). British Patent 1,144,068. Mar. 5, 1969. Priority date June 16, 1965, Belgium.

Reactor fuels of mixed carbides of the actinides and metals of groups IVB and VB are produced by heating a mixture of a fluoride of one or more actinides, a complex fluoride of a metal of group IA, as $K_2ZrF_6$, carbon, and Al, and then separating, by sublimation, the mixed carbides from the cryolite, Al, and $AlF_3$ formed. Specifically mentioned is the preparation of UC-ZrC from a mixture of $UF_4$, $K_2ZrF_6$, or $Na_2ZrF_6$, graphite and Al. (P.G.C.)

**20541** NUCLEAR REACTOR FUEL. Robertson, John Archibald Law (to Atomic Energy of Canada Ltd.). British Patent 1,146,880. Mar. 26, 1969. Filed Dec. 2, 1966.

A method is described for production of shaped fuel based on hypostoichiometric $UO_2$, $PuO_2$, $ThO_2$ or a mixture thereof. The method comprises heat treating a carbon coated shaped body based on the corresponding non-hypostoichiometric dioxide at 1500° to 1900°C; the proportion of carbon used is 0.08 to 0.8%. Substantially all the carbon is removed during such treatment. Amorphous carbon or graphite may be used; graphite may be applied to the dioxide as a colloidal dispersion in alcohol, or carbon by vapor deposition. Examples of the production of hypostoichiometric $UO_2$ and $ThO_2$ bodies are given. (UK)

**20542** NUCLEAR REACTOR FUEL. Robertson, John Archibald Law (to Atomic Energy of Canada Ltd.). British Patent 1,146,879. Mar. 26, 1969. Filed Dec. 2, 1966.

A method is described for production of fuel elements based on shaped hypostoichiometric fuel dioxide. Hypostoichiometry in such fuels results in improved thermal conductivity and desirable thermoelectric properties. Provision is made for in site formation in an assembled fuel element, and desirably within a nuclear reactor. The method comprises contacting shaped sintered and densified non-hypostoichiometric fuel ($UO_2$, $PuO_2$, $ThO_2$, or mixtures thereof) with up to 2 wt. % of shaped bodies of the corresponding fuel metal, and heating the composite material to above 1500°C under non-oxidizing conditions until the oxygen/metal ratio is between 1.90 and 2. The non-hypostoichiometric dioxide fuel bodies may be assembled in contact with fuel metal bodies and heat treatment and reduction to hypostoichiometry carried out on the assembled fuel element, preferably in the reactor where the fuel element is to be used. Where mixed oxides are used the "getter" metal may be either U or Th, and where isotopically enriched $UO_2$ is used the "getter" need only be natural U; alternatively natural $UO_2$ may be used with enriched "getter" metal. Up to 2 wt. % of a non-fuel oxide, such as $ZrO_2$ or $Y_2O_3$, may be included. Examples are described in detail. (UK)

**20543** THE SYNTHESIS OF DOUBLE BORATE MONOCRYSTALS IN THE SYSTEM $Ln_2O_3$–SrO–$B_2O_3$. Dzhurinskii, B. F.; Tananaev, I. V.; Aliev, O. A. (Inst. of General and Inorganic Chemistry, Moscow). Izv. Akad. Nauk SSSR, Neorg. Mater., 4: 1972–4(Nov. 1968). (In Russian).

An isothermal (1100°C) study was made on the system $Ho_2O_3$–SrO–$B2O_3$. Monocrystals of the following double borates were synthesized: $La_2Sr_3(BO_3)_4$, $Pr_2Sr_3(BO_3)_4$, $Nd_2Sr_3(BO_3)_4$, $Gd_2Sr_3(BO_3)_4$, $Tb_2Sr_3(BO_3)_4$, $Dy_2Sr_3(BO_3)_4$, $Ho_2Sr_3(BO_3)_4$, $Er_2Sr_3(BO_3)_4$, and $Yb_2Sr_3(BO_3)_4$. (tr-auth)

**20544** HIGH LOADED $UO_2$–NIOBIUM CERMETS. Fuhrman, Nathan; Gordon, Emanuel; Holden, Robert B. (to Atomic Energy Commission). U. S. Patent 3,429,699. Feb. 25, 1969. Filed July 24, 1967.

A process is described for producing improved $UO_2$–Nb cermets having ceramic phase loadings of over 70 volume %, comprising coating $UO_2$ spheres with wax then with a mixture of powdered niobium and carbon, forming a compact, dewaxing the compact, and heat sintering the compact. The carbon is used to remove oxygen impurities and to increase the theoretical density of the cermet. (Offic. Gaz.)

**20545** DENSE REFRACTORY ZIRCONIUM BORIDE BODIES. Allen, Walter C.; Taebel, Wilbert A. (to National Beryllia Corp.). U. S. Patent 3,433,656. Mar. 18, 1969. Filed Jan. 20, 1967.

By the addition of 1 to 6% tungsten metal to 94% or more zirconium diboride and hot pressing at 1950 to 2200°C at a pressure of 3000 psi or more, dense molded zirconium diboride products may be produced. (Offic. Gaz.)

## *Properties Evaluations*

*Refer also to abstract 21008.*

**20546** (BMI–1857, Sect.C) CREEP OF REACTOR FUEL MATERIALS. (Battelle Memorial Inst., Columbus, Ohio). 40p.

Progress on creep of LMFBR fuel materials is reported including the design, fabrication, and operation of the in-pile creep capsule. Efforts devoted to fabrication, preirradiation compressive creep testing, and mechanisms of creep of $UO_2$ and $UO_2$–$PuO_2$ are reported along with results of creep testing of $UO_2$ and post irradiation compressive creep testing of $UO_2$ and $UO_2$–$PuO_2$. Investigations are reported on stoichiometry of $UO_2$–$PuO_2$. (F.S.)

**20547** OBSERVATIONS CONCERNING THE DETERMINATION OF POROSITIES IN GRAPHITES. Dickinson, J. M.; Shore, J. W. (Los Alamos Scientific Lab., N. Mex.). Contract W-7405-Eng-36. Carbon, 6: 937–41(1968). (LA-DC-8628).

The porosities of a number of graphites were determined by mercury porosimetry and helium intrusion methods, and in addition, vapor pressures and mercury distillation data were obtained on graphite specimens intruded with mercury in a porosimeter. All of the results were in agreement with the conclusions that mercury porosimetry can cause damage to graphite specimens above some critical pressure range, and that this damage can cause the results of porosimetry measurements to be misleading. (auth)

**20548** CHANGES IN THE PROPERTIES OF POWDERS DURING THE PRESSING OF HARD MATERIALS. Krauth, A. (Max-

Planck-Institut fuer Silikatforschung, Wuerzburg, Ger.). Ber. Deut. Keram. Ges., 45: 622-6(Dec. 1968). (In German).

An x-ray method was used to determine the lattice distortions occurring during the pressing of TaC, VC and ZrN powders at various pressures. These distortions were compared with those occurring during grinding. There were considerable differences in the stresses of the three substances used, both after pressing and after grinding. The dislocation densities were estimated (on the basis of the broadening of x-ray lines and of electron photomicrographs) and compared with each other for the three materials. The maximum value was $10^{11}$ $cm^{-2}$. This corresponds to the dislocation density of severely deformed metals. The stresses begin to decrease at 750°C for VC, at 1000°C for ZrN and above 1600°C for TaC. Thus the hard substances investigated show a typical metallic behavior and it is to be expected that the initial vitrification, recrystallization and hence the further sintering will also be found similar to those of metals. (auth)

**20549** CRATERING WEAR IN WC–Co BASE CEMENTED CARBIDES. Suzuki, Hisashi; Yamamoto, Takaharu; Kawakatsu, Ichiro (Tokyo Univ.). Nippon Kinzoku Gakkaishi, 33: 82-8 (1969). (In Japanese).

The mechanisms of cratering formed on the WC–Co base carbide tools were investigated in relation to the carbon contents of both cemented carbides and machined steels. High carbon and low carbon cemented carbide bits, the compositions of which were WC-10% Co, WC-10% TaC-10% Co and WC-10% TiC-10% Co, were vacuum-sintered at 1375°C for 1.5 hr. Using these bits, of the throw away type, various carbon steels, i.e., SK 3 (1.1% C), SK 7 (0.6% C) and S 10 C(0.1% C) and 18-8 type stainless steel of SUS 27 were machined. In WC-Co alloys, the cratering due to the formation of $M_6C$ type carbide was found to develop easily during cutting of low carbon steels or stainless steel, especially in the case of low carbon cemented carbide bits. This phenomenon was based on the diffusion out of carbon from cemented carbides during cutting of the steels. In alloys containing tantalum carbide and titanium carbide, it was found that the TaC or $\beta$ (WC–TiC solid solution) phase on the crater surface changed its carbon content so as to compensate the abrupt change of the carbon content in the binder phase, i.e., in the alloys. For example, the TaC or $\beta$ phase acted as a source of diffusion of carbon when the carbide tool was forced to crater due to the above-mentioned mechanism. It was shown that the carbon contents of both carbide tools and machined steels play an important role in the phenomenon of cratering. (auth)

**20550** THERMODYNAMIC PROPERTIES OF PLUTONIUM NITRIDE BY GALVANOSTATIC POTENTIAL DETERMINATION. Campbell, G. M. (Los Alamos Scientific Lab., N. Mex.). J. Phys. Chem., 73: 350-5(Feb. 1969).

A galvanostatic technique was developed for the determination of equilibrium potentials in fused salts. The technique makes it possible to measure the emf of metal–metal ion couples without requiring the presence of the metal for long periods of time. This has obvious advantages, especially in the case of very reactive metals where surface impurities are difficult to eliminate by the usual techniques. The technique was used to obtain direct measurements on the cell $Pu(s,l)|PuCl_3, LiCl-KCl|N_2(g), PuN(s)$ over the temperature range 714 to 1032°K. The reaction of Pu with $N_2$ at these temperatures precludes obtaining the emf by other methods. Over this temperature range, at 1 atm $N_2$ the emf is $E = 7.90071 - 2.31690 \times 10^{-2}T + 2.517855 \times 10^{-5}T^2 - 9.1644 \times 10^{-9}T^3$ (±0.003) V. Above the melting point of Pu (913°K) the standard free energy of formation of PuN is $-\Delta G_T^0 = 73.8 - 0.0225T$ kcal/mole of PuN. From the condition $S^0_{298}(PuN) - S^0_{298}(Pu) = S^0_{298}(UN) - S^0_{298}(U)$ the estimate $-\Delta H^0_{298} = 72.5$ kcal/mol is made. Theoretical development of the technique is included. (auth)

**20551** ASYMMETRIC CONDUCTION IN THIN FILM TANTALUM/TANTALUM OXIDE/METAL STRUCTURES: INTERSTITIAL AND SUBSTITUTIONAL IMPURITY EFFECTS AND DIRECT DETECTION OF FLAW BREAKDOWN. Axelrod, Norman N.; Schwartz, Newton (Bell Telephone Labs., Inc., Murray Hill, N. J.). J. Electrochem. Soc., 116: 460-5(Apr. 1969).

Asymmetric conduction in a thin film tantalum/tantalum oxide/metal structure depends strongly on the method of preparation of the individual elements as well as the conditions under which the structure is measured. Some of the factors which need to be considered are: gas and alloy metal content of the sputtered tantalum film; structural perfection of the tantalum film; nature of the metal counter electrode; and ambient factors such as the presence of moisture during measurement. The principal results are explained on the basis of flaws in the anodic oxide. Evidence exists, however, that some degree of asymmetric conduction exists in nominally flaw-free films. (auth)

## *Structure and Phase Studies*

**20552** THE UNSTABLE CERMET COMBINATION $U_3O_8$ AND ALUMINIUM. II. THE REACTIVITY AND PROPERTIES OF $U_3O_8$–Al CERMETS. Ondracek, G.; Patrassi, E. (Kernforchungszentrum, Karlsruhe, Ger.). Ber. Deut. Keram. Ges., 45: 617-21(Dec. 1968). (In German).

The classification of cermets into stable, metastable and unstable is explained. The reactions between the components of $U_3O_8$–Al cermets are described. Measurements are compared with the data from the literature. The instability of the system is due to a reaction occurring between its components, which proceeds in two stages: $U_3O_8 + [(43/3) + x]Al \rightarrow 3UO_2 + (2/3)Al_2O_3 + (13 + x)Al \rightarrow (8/3)Al_2O_3 + (3 - x)UAl_3 + x \cdot UAl_4$. The reactions were studied by polarization microscopy, x-ray, electrical-conductivity measurements, chemical analyses, and by thermo-chemical investigations. The reaction products ($Al_2O_3$, $UAl_4$) occur presumably together and have a mutual effect on each other. Of the properties the values for mechanical strength are discussed with particular reference to the measurements of the contact angle. A synoptic account is given of the concentration and temperature functions of tensile strength, modulus of elasticity and electrical resistivity. (auth)

**20553** THE LATTICE CONSTANTS OF THE CUBIC SOLID SOLUTIONS $ZrO_2$–CaO, AND $ZrO_2$–$Y_2O_3$. Baukal, W.; Scheidegger, R. (Brown, Boveri and Cie., Ltd., Baden, Switzerland). Ber. Deut. Keram. Ges., 45: 610-16(Dec. 1968). (In German).

The lattice constants were determined in these systems between 8 and 27 mole % CaO and 6 and 35 mole % $Y_2O_3$. A graph comparing these data with the values from the literature clears up some of the previous discrepancies. In the system $ZrO_2$-CaO the cubic phase ranges at 1400°C from 11.5 to 19.5 mole % CaO. In the regions of heterogeneity the ratio of the equilibrium phases is calculated from a mass balance. A calibration method based on this balance is proposed for the determination of phase boundaries from typical x-ray reflections. In the system $ZrO_2-Y_2O_3$ the fluorite phase extends to at least 35 mole % $Y_2O_3$. With $Y_2O_3$ contents below 8 mole % an anomaly occurs which can be explained by a temperature-dependent curve of a continuous conversion cubic ⇌ tetragonal. The lattice constant of the hypothetical cubic pure $ZrO_2$ is determined from Vegard's law and is extrapolated to high temperatures. Agreement is obtained with direct measurements. (auth)

**20554** THE CRYSTAL STRUCTURE OF RHENIUM(VII) OXIDE. Krebs, Bernt; Mueller, Achim; Beyer, Hans H. (Univ., Goettingen, Ger.). Inorg. Chem., 8: 436-43(Mar. 1969).

The crystal structure of rhenium(VII) oxide, $Re_2O_7$, was determined from three-dimensional single-crystal x-ray data collected by film techniques. The least-squares refinement converges to a conventional R factor of 0.053 for 1126 nonzero reflections. The compound crystallizes in the orthorhombic system, space group $P2_12_12_1$, with a = 12.508, b = 15.196, c = 5.448, and V = 1035.5 Å. The unit cell contains 8 formula units. Measured and calculated densities are 6.14 and 6.214 $g/cm^3$, respectively. The structure consists of strongly distorted $ReO_6$ octahedra and fairly regular $ReO_4$ tetrahedra, which are connected through corners to form polymeric double layers in the ac plane. The double layers have only van der Waals contacts to neighboring ones. Parallel zigzag chains of octahedra, every other chain being part of the upper or lower half of the double layer, are linked through corners of the tetrahedra in such a way that rings (o–t–o–t) (o, octahedron, t, tetrahedron) within the layers are formed. The octahedra contain three short (1.65–1.75 Å) and three long (2.06–2.16 Å) Re–O bonds, while in the tetrahedra the bond distances range from 1.68 to 1.80 Å. The structure is one of the relatively few known examples where metal atoms of the same oxidation number occur with coordination numbers 4 and 6 in the same structure. From the crystal structure the mechanisms of evaporation (to form $O_3ReOReO_3$ molecules) and of hydrolysis (where $Re_2O_7(OH_2)_2$ is formed) can be derived. In its structural and bond properties, rhenium (VII) oxide represents an intermediate between the polymeric oxides $MoO_3$ and $WO_3$ and the more covalently bonded $OsO_4$, which forms a molecular structure. (auth)

**20555** ORIENTED CRYSTALLIZATION IN THE SYSTEM COBALT–TANTALUM–CARBON. Bibring, Herve; Seibel, Georges (Office National d'Etudes et de Recherches Aerospatiales, Hauts-de-Seine, France). Compt. Rend., Ser. C, 268: 144-7(Jan. 13, 1969). (In French).

In the system Co–Ta–C controlled solidification permits

realization of a pseudobinary eutectic in the matrix of cobalt in tantalum carbide aligned parallel to the direction of growth. (tr-auth)

**20556** CROSS SECTION OF THE TERNARY DIAGRAM U–O–N IN THE PLANE $UO_2$–$U_2N_3$. Blum, Pierre-L.; Laugier, Jean; Martin, Jean-Marie (Centre d'Etudes Nucleaires, Grenoble, France). Compt. Rend., Ser. C, 268: 148-51(Jan. 13, 1969). (In French).

The cross section $UO_2-U_2N_3$ of the ternary diagram U–O–N was described precisely by means of x-ray diffraction at high temperature. This is a pseudobinary system presenting a monotectoid at 1070°C for a composition corresponding to $UON_{0.75}$. Furthermore, the existence of a four-phase reaction: $U_2N_{3(ss)} \rightleftharpoons UN_{(ss)} + UO_{2(ss)} + N_2$ is demonstrated. (tr-auth)

## *Radiation Effects*

*Refer also to abstracts 20534–20536 and 20546.*

**20557** (ORNL–4350, pp 67-78) FISSION-GAS RELEASE AND PHYSICAL PROPERTIES OF FUEL MATERIALS DURING IRRADIATION. (Oak Ridge National Lab., Tenn.).

Equipment and procedures used to determine the amount of nonfission heating required for in-reactor thermal diffusivity measurements are described as are the effects of temperature, fission density, and burnup on the thermal diffusivity and fission-gas release of UN, sol-gel, and high density spheres and pellets of $PuO_2-UO_2$ fuels. A new technique, involving coating specimens with molten naphthalene, was developed for handling $PuO_2$ specimens outside of glove boxes. (auth)

**20558** (ORNL–4350, pp 139-45) BEHAVIOR OF REFRACTORY MATERIALS UNDER IRRADIATION. (Oak Ridge National Lab., Tenn.).

Research on the effects of high fast-neutron fluences, at 150 to 1100°C, on the properties of non-fissionable ceramic materials, the carbides, nitrides, and silicides of refractory metals was continued. Explosion-pressed carbides of Nb, Ti, and Zr, expanded less during irradiation at 100 to 1100°C than at 300 to 700°C. Dimensional measurements on carbides irradiated at 300 to 700°C showed an initial expansion that reached a maximum between 1 and $2 \times 10^{21}$ neutrons/cm$^2$. Higher fluences produced shrinkage. Commercial nitrides of Nb, Ta, Ti, and Zr were irradiated at 1000 to 1100°C at neutron fluences from 0.4 to $2.3 \times 10^{21}$ neutrons/cm$^2$. Damage was less than in previous experiments conducted at 150°C. A definite in-reactor thermal effect was noted in their volume expansion. (P.G.C.)

**20559** (ORNL–4350, pp 146-7) FAST-NEUTRON IRRADIATION EFFECTS ON ELECTRICAL INSULATORS. (Oak Ridge National Lab., Tenn.).

The program to study the effects of fast neutrons on materials suitable for electrical insulators in thermionic converters and to evaluate neutron damage in these materials from 150 to 1100°C continued. Assemblies of large grain translucent $Al_2O_3$, sintered MgO, metal-clad $Al_2O_3$, and $Si_2ON_2$ are undergoing fast neutron irradiation. (auth)

# Plastics and Other Materials

*Refer also to abstracts 19692, 20524, 21451, and 21484.*

**20560** (RD/B/N–1178) A REVIEW OF MASS SPECTROMETRIC STUDIES RELATED TO GRAPHITE CORROSION IN THE MAGNOX AND AGR SYSTEMS. Evans, H. E.; Jennings, P. P. (Central Electricity Generating Board, Berkeley (England). Berkeley Nuclear Labs.). Jan. 1969. 14p. Dep.

The results obtained in recent mass spectrometric studies of the species produced in a number of relevant gases by electron bombardment and gas discharges are briefly reviewed. The results are related to the graphite corrosion reactions in Magnox and AGR reactors. (UK)

**20561** GAMMA RADIATION DAMAGE OF STRUCTURAL CONCRETE IMMERSED IN WATER. Sommers, John F. (Idaho Nuclear Corp., Idaho Falls). Health Phys., 16: 503-8(Apr. 1969).

Concern for the integrity of the Materials Testing Reactor canal walls prompted the testing of structural concrete samples for damage due to intense and prolonged gamma radiation exposures. Testing of the samples by breaking them under compression following gamma exposures up to $2 \times 10^{11}$ R indicated a progressive loss of strength with increasing gamma irradiation. Very extensive surface deterioration of the specimens occurred when they were subjected to gamma radiation and when the water in which they were submerged during irradiation was free to circulate away from the concrete samples. The surface deterioration was also progressive with increasing gamma exposures. Some anomalies occurred that were unexplained, but in general should not affect the general conclusion of a 50% loss of strength with gamma exposures of up to $2 \times 10^{11}$ R. (auth) (UK)

# PHYSICS (GENERAL)

## Astrophysics and Cosmology

**20562** EQUATION OF RADIATIVE TRANSFER IN A MAGNETOACTIVE PLASMA. Zheleznyakov, V. V. (Radiophysical Research Inst., Gorky, USSR). Astrophys. J., 155: 1129-31 (Mar. 1969).

The equation of radiative transfer in a nonuniform magnetoactive medium is derived from the equation of continuity for the density of radiative energy in the space of coordinates and wave vectors. In particular, it follows from the equation obtained, which is valid when the ray configuration is given by the geometrical optics approximation, that $I|\cos\vartheta|/n^2$ is invariant when the radiation is propagating in a nonuniform, nonabsorbing, and nonradiative medium. Here I is the specific intensity of the radiation, n is the index of refraction of the medium, and $\vartheta$ is the angle between the phase and group velocities, which, in a magnetoactive plasma, is in general not equal to zero. (auth)

### Cosmic Ray Exposure Ages

**20563** COSMOGENIC RARE GASES AND THE $^{40}K$–$^{40}Ar$ AGE OF THE KODAIKANAL IRON METEORITE. Bogard, D. D.; Burnett, D. S.; Wasserburg, G. J. (California Inst. of Tech., Pasadena). Earth Planet. Sci. Lett., 5: 273-81(Jan. 1969).

Measurements were made of the cosmogenic He, Ne, and Ar in the metal phase and of the K–Ar ages of two glass inclusions in the Kodaikanal iron meteorite. The small amounts of cosmogenic rare gas are best interpreted as due to a low cosmic-ray exposure age. From empirical production rates, ages of 12, 15, and 15 m.y. were obtained from the $^{3}He$, $^{21}Ne$, and $^{38}Ar$ concentrations, respectively. The $^{3}He/^{21}Ne$, $^{3}He/^{4}He$, and $^{4}He/^{38}Ar$ ratios are all consistent with low shielding during the exposure. The feldspar and glass have approximately equal K–Ar ages of $3.5 \pm 0.1$ and $3.3 \pm 0.1 \times 10^{9}$ yr, respectively. These results place constraints on possible origins for the glass and feldspar. (auth)

**20564** CHEMICAL COMPOSITION OF NUCLEI OF Z > 22 IN COSMIC RAYS USING METEORITIC MINERALS AS DETECTORS. Lal, D.; Rajan, R. S.; Tamhane, A. S. (Tata Inst. of Fundamental Research, Bombay). Nature (London), 221: 33-7 (Jan. 4, 1969).

New techniques are discussed, which considerably extend the usefulness of meteoritic minerals in the study of the composition of prehistoric cosmic radiation. (auth)

### Stars

**20565** HD 191980: A PECULIAR B-TYPE STAR. Keenan, P. C.; Slettebak, A.; Bottemiller, R. L. Astrophys. Lett., 3: 55-8(Feb. 1969).

The B-type star HD 191980 shows a peculiar spectrum in the sense that different spectral features yield different spectral types, ranging from B3 to B8. The color of the star suggests that the earlier type is more nearly representative. Particularly striking is the unusual helium-to-carbon line-intensity ratio, in which UD 191980 shows similarities to several other peculiar B-type stars including BS 5378 and $\alpha$ Scl. The strength of the interstellar D lines suggests an absolute magnitude near −1 for this object. Radial velocity measurements during recent years differ from earlier measurements but whether this represents an intrinsic variation is not yet clear. (auth)

**20566** RELATION BETWEEN THE VISCOSITY OF A PLASMA AND THE POSSIBLE GENERATION OF A CONSTANT MAGNETIC FIELD IN A STAR. Cattani, D. (Univ., Bologna. Istituto Nazionale di Fisica Nucleare, Bologna). Nuovo Cim., Lett., 1: 343-5(Feb. 21, 1969).

The contribution of the viscosity of a plasma to the explanation of stellar magnetic fields is considered. If the atmosphere is continuously expanding equilibrium cannot be reached and, where expansion is subsonic, the viscous forces will work to dissipate part of the star's momentum. Angular momentum transfer in the stellar atmospheric plasma is investigated. (W.D.M.)

**20567** ON THE CHEMICAL COMPOSITION AND AGE OF NGC 188. Demarque, Pierre; Schlesinger, Barry M. (Univ. of Chicago). Astrophys. J., 155: 965-71(Mar. 1969).

Stellar models for a wide range of chemical compositions are constructed in an attempt to explain the presence of a gap above the main sequence in the C–M diagram of NGC 188. The procedure of fitting the theory to the observations is described. Agreement with observation is obtained for a high value of the metal content, $Z \simeq 0.07$. The corresponding age for the cluster is of the order of $7 \times 10^{9}$ years. (auth)

**20568** ON THE INTERPRETATION OF THE COLOR–MAGNITUDE DIAGRAMS OF M67 AND NGC 188. Aizenman, Morris L.; Demarque, Pierre; Miller, R. H. (Univ. of Chicago). Contract NSF GP-8109. Astrophys. J., 155: 973-86(Mar. 1969).

A method for determining the helium content Y, for a given Z, of old galactic clusters is described. This method could be of considerable importance since it is independent of the distance modulus of the cluster and of color corrections such as those due to interstellar reddening and differential line blanketing. It is found that Y is proportional to the width of the gap of the C–M diagram just above the main sequence. In order to calibrate this effect, a number of theoretical evolutionary tracks was obtained from the main sequence to beyond the hydrogen-exhaustion phase for different chemical compositions. A statistical analysis of the data of Eggen and Sandage was made which confirms the presence of such a gap in M67 and NGC 188. It shows that the gap width has a well-defined value equal to $0.167 \pm 0.010$ mag in M67. This last result yields $Y = 0.38 \pm 0.02$ at $Z = 0.03$ and $Y = 0.28 \pm 0.02$ at $Z = 0.06$. Higher Y-values would be required if Z is as low as 0.01. The corresponding ages for M67 are about $3.5 \times 10^{9}$ years for $Y = 0.38$, $Z = 0.03$, and $2.6 \times 10^{9}$ years for $Y = 0.28$, $Z = 0.06$. In NGC 188, the gap, although present, does not appear to be fully developed, which leaves some uncertainty as to its chemical composition if this method is used. (auth)

**20569** ON THE OSCILLATIONS AND STABILITY OF ROTATING STELLAR MODELS. II. RAPIDLY ROTATING WHITE DWARFS. Ostriker, Jeremiah P.; Tassoul, Jean Louis (Princeton Univ. Observatory, N. J.). Contract AF 49(638)-1555. Astrophys. J., 155: 987-97(Mar. 1969).

The stable and unstable oscillations of rapidly rotating, zero-temperature white dwarfs are considered. The models are axisymmetric, and the angular velocity depends only on the distance from the axis of rotation. Approximate expressions for the lowest seven modes were obtained for uniformly and nonuniformly rotating models. It is not assumed that rotational effects are small. It is shown that, for sufficiently high values of the ratio of kinetic to potential energy $T/|W|$, nonuniformly rotating white dwarfs may become overstable. This instability is directly analogous to an instability of the classical homogeneous Maclaurin spheroids that has been considered a precursor of fission. A neutral mode, associated with a nonaxisymmetric Kelvin oscillation, can be found exactly and occurs when $T/|W| \simeq 0.14$, the latter value being almost independent of the total mass and angular-momentum distribution. In cases where viscous forces are important, the models become secularly overstable when $T/|W| > 0.14$, but then adjacent triaxial configurations exist which carry on the stability. In the absence of viscosity, dynamical overstability occurs via the same non-axisymmetric mode when $T/|W| \gtrsim 0.26$, almost independently of the total mass and angular-momentum distribution. Due to the fact that, for uniformly rotating white dwarfs, the kinetic energy is restricted to the range $0 \leq T/|W| \lesssim 0.06$, these models are always stable with respect to nonaxisymmetric disturbances. All the white dwarf models constructed by Ostriker and Bodenheimer above the mass limit for nonrotating stars are dynamically stable to the modes considered. (auth)

**20570** SPECTROPHOTOMETRIC STUDIES OF GASEOUS NEBULAE. XII. THE SYMMETRICAL PLANETARY IC 3568. Lee, Paul (Louisiana State Univ., Baton Rouge); Aller, Lawrence H.; Czyzak, S. J.; Duvall, Rhonda N. Astrophys. J., 155: 853-8(Mar. 1969).

A photoelectric spectrum scanner and conventional technique of photographic spectrophotometry were used to derive the relative intensities of spectrum lines for the bright, compact, symmetrical, medium-excitation planetary nebula IC 3568. The nebula appears to be unaffected by space absorption. The agreement between the observed and theoretical Balmer decrement seems to be excellent. (auth)

**20571** EFFECTS OF SELF-ABSORPTION AND INTERNAL DUST ON HYDROGEN-LINE INTENSITIES IN GASEOUS NEBULAE. Cox, Donald P.; Mathews, William G. (Univ. of California, San Diego). Astrophys. J., 155: 859-69(Mar. 1969).

A general method for computing hydrogenic recombination decrements in gaseous nebulae is described. The effects of any combination of partial Lyman-line leakage (for cases intermediate between case A and case B), Balmer-line self-absorption, and internal dust can be calculated from known case A decrements. In particular, for a homogeneous spherical nebula, the com-

bined effects of Balmer-line self-absorption and partial Lyman-line leakage in terms of optical depths in Hα and Lyman α were calculated. The relevance of these calculations for real nebulae is discussed. Finally, the influence of small graphite grains and other particles within the nebula on the Balmer decrement is discussed. (auth)

**20572** STAR FORMATION IN INTERSTELLAR CLOUDS: STUDIES WITH A MODIFIED VIRIAL THEOREM. Arny, Thomas (Univ. of Massachusetts, Amherst). Astrophys. J., 155: 871-4(Mar. 1969).

The virial theorem is extended to study the development of condensations in a larger gas cloud. Fragmentation is found to occur most readily in the interior regions. The cloud pressure gradient has only a small effect on the growth. Apart from a tidal retarding action, instability is governed by local conditions. (auth)

**20573** FAR-ULTRAVIOLET SPECTRA OF ZETA PUPPIS AND $\gamma^2$ VELORUM. Morton, Donald C.; Jenkins, Edward B.; Brooks, Neil H. (Princeton Univ., N. J.). Contracts NAS5-1810; NSr-31-001-901. Astrophys. J., 155: 875-85(Mar. 1969).

Far-ultraviolet spectra with about 1.6-Å resolution were photographed with an all-reflective objective spectrograph on an Aerobee rocket on November 1, 1967. Spectra were obtained of the O5f star ζ Puppis from 1100 to 1965 Å and the WC8 + O7 star $\gamma^2$ Velorum from 1127 to 1193 Å. The width of the interstellar Lyman-α absorption line in ζ Pup corresponds to $4.8 \times 10^{19}$ hydrogen atoms $cm^{-2}$ in front of the star. If the outer edge of its H(II) region is 390 pc away the average volume density of neutral hydrogen is only 0.040 atoms $cm^{-3}$. Interstellar absorption lines of C(II), N(I), Al(II), Si(III), S(III), Fe(II), and Fe(III) also may be present in the ζ Pup spectrum. Strong resonance absorption lines of C(IV), N(V), Si(III), and Si(IV) and an excited line of C(III) (6.5 eV) are present in ζ Pup with velocity shifts averaging 1810 km $sec^{-1}$ toward shorter wavelengths. These lines must be formed in an expanding shell escaping from the star, similar to the shells found in the hot supergiants in Orion. Excited absorption lines of He(II) (40.6 eV) and N(IV) (16.1 eV) have lesser shifts of 350 and 780 km $sec^{-1}$, respectively, and therefore must be formed lower in the atmosphere where the acceleration occurs. Emission lines of He(II), C(IV), N(IV), and N(V) are visible close to their laboratory wavelengths. Photospheric lines of C(III), C(IV), N(III), N(IV), O(IV), Ar(IV), Fe(IV), and Fe(V) also seem to be present in ζ Pup. (auth)

**20574** ON THE NATURE OF FAINT BLUE OBJECTS IN HIGH GALACTIC LATITUDES. II. SUMMARY OF PHOTOMETRIC RESULTS FOR 301 OBJECTS IN SEVEN SURVEY FIELDS. Sandage, Allan; Luyten, Willem J. (Carnegie Institution of Washington, D. C. California Inst. of Tech., Pasadena). Astrophys. J., 155: 913-18(Mar. 1969).

The results of UBV photoelectric photometry for 301 blue objects in intermediate to high galactic latitudes are summarized. The magnitudes of all but three of the objects lie in the range $14.5 < V < 19.2$. The majority of the bluer objects lie near the black-body line. They generally avoid the luminosity class III–VI line of the U–B, B–V diagram. The major constituents appear to be white dwarfs, quasistellar objects which are radio quiet to 9 flux units at 178 MHz, and F to G subdwarfs. Nine possible horizontal-branch stars in the range $0.05 \leq B - V < 0.25$ are present in the sample. Estimates from three sets of data, including a first photoelectric study of faint blue objects with $19 < B < 22$ in SA 57, suggest that the number of QSOs per square degree brighter than magnitude B is at least as high as $\log N(B) \simeq 0.75\ B - 14.0$. The tentative nature of this first determination is stressed. If correct, there are of the order of $10^7$ QSOs over the entire sky brighter than B = 22. (auth)

**20575** ULTRASHORT-PERIOD STELLAR OSCILLATIONS. III. POWER-SPECTRUM ANALYSIS OF PHOTOMETRIC OBSERVATIONS OF WHITE DWARFS. Hesser, James E.; Ostriker, Jeremiah P.; Lawrence, George M. (Princeton Univ. Observatory, N. J.). Astrophys. J., 155: 919-33(Mar. 1969).

Photometric observations of white-dwarf stars obtained in digital form at the time of observation are analyzed by power-spectrum techniques; the resultant power spectra are most reliable for Fourier components with periods in the 2- to approximately 360-sec range. Details of the power-spectrum analysis are presented, with emphasis upon the avoidable pitfalls of the method. Except for the peculiar blue object HZ 29, the observed white dwarfs possess quiet or flat, low-level power spectra, and do not show periodic variability in the statistically valid period range. Limits to the maximum Fourier amplitude can in some cases be set to <0.003 mag. Graphs are given for the power spectra of a typical "quiet" white dwarf and for HZ 29, the latter showing peaks at ≈525 sec and ≈1050 sec. (auth)

**20576** RED SUPERGIANTS AND NEUTRINO EMISSION. Stothers, Richard (Goddard Space Flight Center, New York). Astrophys. J., 155: 935-56(Mar. 1969).

Data on the supergiants in all early-type clusters and associations of the Galaxy and Magellanic Clouds which contain known red-supergiant members were collected and analyzed in the light of current theory. No major differences seem to exist between the Galaxy and the Magellanic Clouds in this study. The composite bolometric H–R diagram for the "M associations" shows (1) many blue supergiants (O9.5-A5) mostly in the range B0-B3 with $M_{bol} \sim -6$ to $-10$; (2) a roughly equal number of red supergiants (M0-M4.5) mostly in the range M0-M2, but the brightest being latest in spectral type, with $M_{bol} \sim -5$ to $-8$ and no correlation with luminosity class; and (3) a thin scatter of yellow supergiants (F, G, and K). Dating of the clusters from the luminosities of their blue supergiants indicates decreasing and increasing numbers of blue and red supergiants, respectively, with age. Luminosity functions show that the blue/red ratio is >5 at high masses (15 to 60 $M_\odot$) and ~1 at lower masses (10 to 15 $M_\odot$). While a one-to-one correspondence exists between luminosity and mass for the core helium-burning blue supergiants, it is lacking for the red supergiants because of a "funneling effect" (in analog with the K giants). The red supergiants are shown theoretically to be in two basically different evolutionary phases: (1) helium core contraction and early core helium burning and (2) carbon core contraction and later phases. The first case explains the blue/red ratio at low masses. The second case refers to high masses and depends on the existence of the hypothetical photoneutrino process; the predicted blue/red ratio is <17 and <1.7 with and without the neutrino process, respectively. On the basis of the large blue/red ratio among the most massive supergiants and the independent theoretical and observational evidence that early core helium burning occurs in the red-supergiant region, it is concluded that some effect must take massive stars rapidly through, or away from, the red-supergiant region after core helium burning. Mixing and mass loss are shown to be inadequate mechanisms. If photoneutrino losses are permitted to occur, the stars do evolve rapidly as red supergiants, as required by the observations. One might accept this as supporting evidence for the existence of a direct electron–neutrino weak interaction in nature. (auth)

**20577** SIX-COLOR PHOTOMETRY OF STARS. XII. COLORS OF HYADES AND SUBDWARF STARS. Sears, R. L.; Whitford, A. E. Astrophys. J., 155: 899-912(Mar. 1969).

Six-color measures in the system of Stebbins and Whitford were obtained for 159 field stars, including many subdwarfs and high-velocity stars. Colors were also obtained for fifty Hyades stars. Ultraviolet excesses are demonstrated for the subdwarfs with respect to the Hyades, and applications toward the determination of temperatures for subdwarfs are indicated. An absolute magnitude versus color (G–I) diagram for the Hyades is shown to fit well the main sequence for nearby field stars. Available data for the cooler subdwarfs indicate that these fall below the main sequence. (auth)

**20578** CONTINUUM ABSORPTION BY HEAVY ELEMENTS IN HIGH-EXCITATION PLANETARY NEBULAE. Harrington, J. Patrick (Univ. of Maryland, College Park). Astrophys. J., 155: 1117-19(Mar. 1969).

The optical depth at wavelengths less than 110 Å due to continuous absorption by ions of nitrogen, oxygen, and neon is estimated and found to be less than unity for several high-excitation planetaries. (auth)

**20579** FLARE STARS IN THE COAL SACK. Sanduleak, N. Astrophys. J., 155: 1121-2(Mar. 1969).

The recent discovery of three flare stars in the region of the Coal Sack indicates that a concentration of such stars is associated with this dark cloud. The observational characteristics of this proposed new flare-star aggregate are compared with the known characteristics of several well-established flare-star aggregates. (auth)

**20580** THE SPECTRA OF NOVA VULPECULAE. Bloch, Marie (Observatoire de Haute Provence, Saint-Genis-Laval, France. Observatoire de Lyon, Saint-Genis-Laval, France). Compt. Rend., Ser. A, B, 268: 107-9(Jan. 6, 1969). (In French).

An analysis of the spectra of Nova Vulpeculae is presented. The spectral lines of each element present in this star are listed and described. (J.F.P.)

**20581** SATELLITE COMPONENTS OF SPECTRAL LINES FORMED IN A DIFFERENTIALLY ROTATING DISK. Magnan, Christian (Institut d'Astrophysique, Paris). Compt. Rend., Ser. A, B, 268: 104-5(Jan. 6, 1969). (In French)

The line profiles formed in a differentially rotating disk have an unexpected structure characterized by the appearance of

"satellite" lines. Such profiles seem to be observed in certain stars. (tr-auth)

**20582** ECLIPSING VARIABLE STARS PHOTOELECTRICALLY OBSERVED DURING THE YEARS 1966–1967 AT THE ASTRONOMICAL OBSERVATORY OF BUCHAREST. Minti, H. (Observatorul Astronomic, Bucharest). Stud. Cercet. Astron., 13: 165-83(1968). (In Rumanian).

Some photoelectric photometer improvements of the Bucharest Astronomical Observatory and the eclipsing binary observations in 1966–1967 are presented. Twelve photoelectric minima were performed: 44 i Boo (four), V 566 Oph, TV Cas, $\beta$ Per, V 836 Cyg (two), RZ Cas, and XTri (two), and the mean curve for the six observation nights of the 44 i Boo star. All observations were carried out without filter. (auth)

**20583** SPECTRUM OF NML CYGNUS FROM 7.5 TO 14 MICRONS. Stein, Wayne A. (Univ. of California, San Diego, Univ. of Minnesota, Minneapolis); Gaustad, John E.; Gillett, F. C.; Knacke, R. F. Astrophys. J., 155: L177-9(Mar. 1969).

The peculiar infrared object NML Cygnus was observed from 7.5 to 14 $\mu$ with a resolution of about $\Delta\lambda/\lambda = 0.013$. No definite absorption features were found in this range of wavelengths. However, combination of these data with other infrared observations leads to a proposed model for this object involving circumstellar infrared emission similar to that observed from other objects. (auth)

**20584** CIRCUMSTELLAR INFRARED EMISSION FROM COOL STARS. Woolf, N. J.; Ney, E. P. (Univ. of Minnesota, Minneapolis). Astrophys. J., 155: L181-4(Mar. 1969).

From a recalibration of published spectra of cool stars in the wavelength region 3 to 14 $\mu$, it is shown that most of the emission from 10 to 14 $\mu$ is circumstellar rather than photospheric. Broadband photometry shows the emission in giants later than M5 and in M2 supergiants but not in some cool carbon stars. The spectrum of the emission resembles that predicted from mineral grains. The carbon star R Leporis has an emission feature in its spectrum unlike that of the M stars. (auth)

**20585** COMPOSITION OF CIRCUMSTELLAR GRAINS. Gilman, Robert C. (Goddard Inst. for Space Studies, New York). Astrophys. J., 155: L185-7(Mar. 1969).

On the basis of calculations of molecular equilibrium, it appears likely that circumstellar grains of oxygen-rich cool stars will be composed mainly of refractory silicates such as $Mg_2SiO_4$ and $Al_2SiO_5$. For carbon-rich stars the grains are mainly carbon, while for the transition stars silicon carbide predominates. (auth)

**20586** POSSIBLE IDENTIFICATION OF INTERSTELLAR SILICATE ABSORPTION IN THE INFRARED SPECTRUM OF 119 TAURI. Knacke, R. F. (Univ. of California, Berkeley); Gaustad, J. E.; Gillett, F. C.; Stein, W. A. Astrophys. J., 155: L189-92(Mar. 1969).

The infrared spectrum of the reddened M supergiant 119 Tauri was observed at low resolution from 2.9 to 12 $\mu$. Broad absorption features at 5 and 8 $\mu$, similar to those in other M-star spectra, are attributed to the fundamental vibration–rotation bands of CO and SiO molecules in the stellar atmosphere. Additional features at 9.7 and 10.6 $\mu$ may be produced by a silicate mineral, possibly $(Mg,Fe)SiO_3$, in the interstellar grains. (auth)

**20587** INFRARED SOURCES IN THE TRAPEZIUM REGION OF M42. Ney, E. P. (Univ. of Minnesota, Minneapolis); Allen, D. A. Astrophys. J., 155: L193-6(Mar. 1969).

The center of the Orion Nebula was mapped at 11.6 and 20 $\mu$. The structure is dominantly double. One source of about 30″ radius appears in the vicinity of the Trapezium stars. A second extended region occurs about 1′ northwest of this. The second, brighter source consists of a previously discovered point source (Becklin–Neugebauer protostar) with extended wings that dominate the long-wavelength emission (Kleinmann–Low infrared nebula). The observations indicate that the Trapezium nebula is optically thin in the infrared, with opacity decreasing to the longer wavelength. Both extended regions could be interpreted as low-mass shells of dust and gas heated by single hot stars. (auth)

**20588** SPECTRAL DISTRIBUTION OF INFRARED RADIATION FROM THE TRAPEZIUM REGION OF THE ORION NEBULA. Stein, Wayne A. (Univ. of California, San Diego, Univ. of Minnesota, Minneapolis. Kitt Peak National Observatory, Tucson, Ariz.); Gillett, F. C. Astrophys. J., 155: L197-9(Mar. 1969).

Radiation at infrared wavelengths from 7 to 14 $\mu$ was detected from the region between the stars of the Trapezium in the Orion Nebula with a field of view of 15″. It was found that the spectral distribution of this radiation resembles closely the spectral distribution of excess radiation observed at these wavelengths from some cool stars. The spectral distribution observed resembles that expected from minerals, such as those in meteoritic material. (auth)

**20589** STELLAR Li/Be AND $^6Li/^7Li$ RATIOS. Conti, Peter S. (Univ. of California, Santa Cruz). Astrophys. J., 155: L167-9(Mar. 1969).

The recent change of a factor of 20 in the solar beryllium abundance leads to Li/Be ratios of the order of 200 for early F stars. New measures of $^6Li/^7Li$ in these same stars indicate the absence of $^6Li$. Spallation processes may have differed between F- and G-type stars. (auth)

**20590** CONTINUUM OF BL LAC. Visvanathan, N. (Harvard Coll. Observatory, Cambridge, Mass.). Astrophys. J., 155: 133-7(Mar. 1969).

Multichannel-scanner observations from 5820 to 10860 Å, polarization observations from 4700 to 7980 Å, and photoelectric UBV observations were obtained for the star BL Lac. The red and infrared continuum is smooth and has a steep slope $P(\nu) \propto \nu^{-2.78}$. UBV observations show excess in the ultraviolet. The continuum is highly polarized, and the polarization is constant in the wavelength range observed. These results can be explained if the major portion of the continuum of BL Lac is of synchrotron origin. Further, identification of the radio source VRO 42.22.01 with BL Lac can be taken to confirm the nonthermal nature of the continuum of BL Lac. (auth)

**20591** HIGH-DENSITY CONDENSATIONS IN H II REGIONS. Mendis, D. A. (Univ. of Manchester, Eng.). Mon. Notic. Roy. Astron. Soc., 142: 441-52(1969).

The state of the hydrogen gas in high-density condensations in H II regions, such as the globules in Orion Nebula, is concluded to be molecular. The assumption that the conditions at the bright rims of these condensations are D-critical is examined. It is shown that this assumption is valid only when the colour temperature of the exciting star is comparatively low. With higher stellar temperatures the conditions at the front are strong D-type. In the latter case the gas speed behind the front can be determined uniquely when the colour temperature of the exciting star is known. With stellar temperatures around $5 \times 10^4$°K these speeds are about twice the isothermal sonic speed in the ionized region. (auth) (UK)

**20592** IONIZATION EQUILIBRIUM WITH NEGATIVE ION FORMATION. Carson, T. R. (Univ. of St. Andrews, Scotland). Mon. Notic. Roy. Astron. Soc., 142: 409-11(1969).

It is shown that the formation of negative ions imposes an upper limit on the free electron density in a plasma under ionization equilibrium conditions. This provides a simple explanation of the fact that calculations of ionization equilibrium in stellar atmospheres break down when the electron density is used as an independent variable and too high a value is specified. (auth) (UK)

**20593** CONTINUOUS ABSORPTION BY MEMBERS OF THE Li ISOELECTRONIC SEQUENCE. McDowell, M. R. C.; Chang, Edward S. (Royal Holloway Coll., Englefield Green, Eng.). Mon. Notic. Roy. Astron. Soc., 142: 465-71(1969).

A polarized Hartree–Fock model is used to compute photoionization cross sections for Li I, Be II, B III, C IV, N V, O VI, F VII, and Ne VIII. Phase shifts for the $l = 0$ and $l = 1$ partial waves of the electron scattered by the corresponding two-electron core are listed at two energies and permit determination of the nonhydrogenic corrections to the free–free absorption. (auth) (UK)

## *Quasi-Stellar, Radio, and X-Ray Sources*

**20594** (NP-17806) [PROGRESS REPORT], 1965–1968. (Commonwealth Scientific and Industrial Research Organization, Sydney (Australia). Radiophysics Lab.). 28p. Dep.

Short summaries of the research progress are given for the programs on the performance of the 210-foot radiotelescope, the 210-foot–60-foot interferometer, receiver developments, mapping the sky for radio sources, interplanetary scintillations, galactic magnetic fields, OH in interstellar space, hydrogen recombination lines, the Large Cloud of Magellan, hydrogen in distant galaxies, pulsed radio sources, solar radio emission, cloud physics, convection and convective cloud, sampling ice nuclei, counters for natural ice nuclei, activation of ice nuclei, and rainmaking. (W.D.M.)

**20595** ASTRONOMICAL CLOCKS IN THE SKY: THE PULSARS. de Closets, Francois. Sci. Avenir, No. 259, 697-701; 770(Sept. 1968). (In French).

An account of recent advances in the speculation about pulsars is given. The original end of the studies being pursued when this discovery was made, study of radio sources of small angular dimensions by scintillation, is explained. The observations of interferences were not explicable by interactions with satellites, radar reflections from the Moon, or other suggestions. The spectrum of the signal is compared with other sources; the period of each pulsar is defined, with the period of Pulsar 1 noted as 1.3372795 sec; the division of the signal into subimpulses has value in determining the size of the source, which appears to be 3000 km. Problems of interpretation of the reproducibility of intensity and of the spectrum of the signals are outlined. Their distance may be determined from delay in receipt of low frequencies and the density of interstellar plasma to be close: 100 to 400 light years. Problems of identification of radio sources with optical sources are reviewed. (BBB)

**20596** PULSARS: THE LATEST SURPRISE FROM RADIO ASTRONOMY. Roberts, James (Univ. of Toronto). Sci. Forum, 1: 22-4(Oct. 1968).

The nature of pulsar radiation and information which can be derived from it about its source are reviewed. The pulses have been measured over the whole range of radio frequencies from the short-wave band (30 MHz) up to the microwave region (3000 MHz). While the timing is just as precise at all these frequencies, a given pulse arrives systematically earlier at the high frequencies. For a given pulsar, the delay at one frequency appears to be always the same, but the delay increases with decreasing frequency precisely proportionally to the inverse square of the frequency. This would be expected if, at the source, the pulses at all the frequencies were generated at the same instant, but they then traveled to Earth through the partially ionized gas between the stars. Observations show that each pulse is itself made up of subpulses. Each pulse consists of a series of very short pulses (~0.3 msec long) with some of the short pulses being circularly polarized. When averaged over a slightly longer time (a few msec), the very short pulses are smoothed out but the pulse still contains structure (typically a double pulse with the relative amplitudes and polarizations of the 2 subpulses being characteristic of each source). Another characteristic of the pulsars is their variability. On some days a pulsar will give strong pulses, on other days it will be undetectable. Even on the days of strong pulses only some of the pulses are strong. At some frequencies, every pulse will be strong for perhaps 30 sec or more, but at other frequencies only sporadic pulses are strong and many are missing. At higher frequencies a pulse that is strong at one frequency tends to be strong at another frequency, but this is not true at the lower frequencies. Possible significance of the combination of extreme accuracy of timing with great variability of amplitude is discussed. To pulse or rotate as rapidly as once per sec a star must be of very small diameter and be very dense. Probably the white dwarfs and certainly the hypothetical neutron stars could rotate at this rate. It is generally accepted that in pulsars the radiating electrons must move in some coordinated way. They may spiral in a magnetic field, but other possibilities exist. Analogies have been sought with the radio emission of the Sun and of the planet Jupiter, both of which can emit strong, short bursts of radio power. (BBB)

**20597** RADIO PULSES FROM THE UNIVERSE. Priester, Wolfgang; Grewing, Michael (Univ. of Bonn). Bild Wiss., 5: 988-98(Nov. 1968). (In German).

A review of progress in the observation of pulsars and in the interpretation of the pulsar phenomenon is given. Observations of the first pulsar at Cambridge, and announcements of 8 others up to August 1968, are recorded; the calculations based on a galactic density of 0.1 electron/cm$^3$ which show a distance of 100 to 650 light years for these objects are described. Attempts to correlate the radio sources with optical sources are noted. Theories of the structure of such sources are outlined; in particular, models corresponding to double stars, rapidly rotating stars, and pulsating stars are described. Some properties of matter under such conditions are noted briefly, particularly for neutron stars. Both the rotating and pulsating models are concluded to be suitable explanations at the present time. (BBB)

**20598** BRIEF DESCRIPTION OF THE PRESENT STATE OF X-RAY ASTRONOMY. Rossi, Bruno (Massachusetts Inst. of Tech., Cambridge). Rend. Semin. Mat. Fis. Milano, 38: 19-40(1968). (In Italian).

The main lines of research in the study of localized sources of extraterrestial x rays are reviewed. The existing data on the better-known sources are analyzed, particular attention being paid to the problem of their identification with optical objects. The distribution of x-ray sources in the Galaxy is studied, and the possibility of observation of extragalactic sources examined. (auth)

**20599** OBSERVATIONS OF THE OCCULTATION OF SAGITTARIUS A BY THE MOON. Thompson, A. R.; Riddle, A. C.; Lang, K. R. (Stanford Univ., Calif.). Astrophys. Lett., 3: 49-50(Feb. 1969).

From two observations of the occultation of the main component of Sagittarius A, the position of the peak brightness is found to be 17 hr 42 min 33.3 sec ± 1.5 sec, −28° 59′ 06″ ± 20″, for epoch 1950.0, and the flux density is 194 ± 15 × $10^{-26}$ Wm$^{-2}$ Hz$^{-1}$ at 405 MHz. (auth)

**20600** A SKY SCAN FOR DISCRETE SOURCES OF GAMMA RAYS IN THE ENERGY REGION 240 TO 1000 keV. Adams, D. J.; Hillier, R. R.; Janes, A. F.; Murray, A.; Redfern, R. M. (Univ. of Bristol, Eng.). Astrophys. Lett., 3: 51-3(Feb. 1969).

A region of the northern sky was searched for discrete sources of gamma rays in the energy interval 240 to 1000 keV. No sources were found with an intensity greater than ≈2 × $10^{-7}$ ergs/cm$^2$ sec. (auth)

**20601** TELEVISION OBSERVATIONS OF THE CRAB NEBULA PULSAR. Sky Telesc., 37: 231(Apr. 1969).

A very brief summary is given of the television observations of Boade's star which is identified as the pulsar NP 0532. 46 photographs were obtained from the video tape, which confirm that the southwest star of the double is in fact the seat of the light flashes. (W.D.M.)

**20602** INTERFEROMETRIC OBSERVATIONS OF THE BRIGHTNESS DISTRIBUTION OF SOUTHERN RADIO SOURCES. Ekers, R. D. Aust. J. Phys., Astrophys. Suppl., No. 6, 1-87 (Mar. 1969).

Observations of 123 southern radio sources were made with the ANRAO two-element variable-spacing interferometer using the east–west and north–south baselines. The observations were made simultaneously at 468 and 1403 MHz with antenna separations from 400 to 1360 ft (191 to 625λ) at 468 MHz and 574 to 1950λ at 1403 MHz). Two-dimensional model brightness distributions are given for 56 of these sources. (auth)

**20603** OPTICAL STUDIES OF PULSAR NP 0532. Duthie, J. G.; Sturch, C.; Richer, H. B.; Rodney, P. (Univ. of Rochester, N. Y.). Science, 163: 1320-2(Mar. 21, 1969).

The period of optical pulsations from NP 0532 was determined to within 2 nanoseconds on three different nights. The time rate of change of the period $(dP/dt)_p$ was 36.17 × $10^{-9}$ second per day. The pulse shape was highly asymmetrical with strong indications of structure. The ratio of the amplitude of the main pulse to that of the interpulse varied with time. No evidence was found for photon coincidences in the pulse on a time scale shorter than 2 microseconds. (auth)

**20604** POLARIZED BRIGHTNESS DISTRIBUTIONS OF SUPERNOVA REMNANTS IC 443 AND W44 AT 6-CM WAVELENGTH. Kundu, M. R.; Velusamy, T. (Tata Inst. of Fundamental Research, Bombay). Astrophys. J., 155: 807-15(Mar. 1969).

Polarized brightness distributions of two supernova remnants, IC 443 and W44, were determined at 6-cm wavelength, from observations made with a resolution of 6′, by using the 140-foot reflector of the National Radio Astronomy Observatory. Both IC 443 and W44 are partially linearly polarized at 6-cm wavelength. The degree of polarization and orientation of electric vectors are different at different parts of IC 443. Over its southeastern rim, the degree of polarization is large, about 4.5%, and the orientation of electric field is largely tangential. Over its northeastern peak, the degree of polarization is low, and the field orientation is random. The distribution of polarized brightness in W44 is broadly similar to that of total intensity. The peak of linearly polarized radiation roughly coincides with the peak of total intensity, and the electric field has a systematic alignment with a position angle of 40° over the main peak as well as over the eastern region. The degree of polarization is negligibly small over the peak of the isolated source situated to the west of W44 around $\alpha = 18^h50^m52^s$ and $\delta = 01°11'30''$, which indicates that it is thermal in nature. (auth)

**20605** POSITIONS AND STOKES PARAMETERS OF SEVEN OH-EMISSION SOURCES. Raimond, Ernst; Eliasson, Baldur (California Inst. of Tech., Pasadena). Contract N00014-67-A-0094-0008. Astrophys. J., 155: 817-30(Mar. 1969).

The two-element, variable-base-line interferometer of the Owens Valley Radio Observatory was used to determine positions of the OH sources near the galactic radio sources W3, Ori A, NGC 6334, Sgr B2, W49, W51, and W75. The accuracy of the absolute positions is 4″ to 6″, that of relative positions of different features belonging to one source is approximately 3″. The relative distances between different components of one source seem to be either between 0.0 and 0.1 pc or between 1 and 10 pc. The

sample of sources may be too small to conclude whether this is a significant property of OH-emission centers. There is a strong indication that four of the OH sources (W3, Ori A, W51, and W75) are located near regions of infrared activity. For three sources, spectra in terms of Stokes parameters are given for the 1665.401-MHz line and for the 1667.358-MHz line. The remaining four sources were observed at 1665.401 MHz only. Strong circular polarization characterizes the spectra of most sources, but many unpolarized and weakly polarized features were found in the spectra of the Ori A and W51 sources. (auth)

**20606** LOW-FREQUENCY ABSORPTION DUE TO IC 1805 AND IC 1848. Roger, R. S. (Dominion Radio Astrophysical Observatory, Penticton, B. C.). Astrophys. J., 155: 831-40 (Mar. 1969).

A map of the radio brightness at 22.25 MHz of an area on the galactic plane ($l^{II} \approx 135°$) including the H(II) regions IC 1805 and IC 1848 is presented. A method is described which makes use of observations of H(II) region absorption at two low frequencies to provide measures of the electron temperature in the region and of the proportions of nonthermal galactic emission originating in front of and behind the region. The kinetic temperatures determined for IC 1805 and IC 1848 from the observations at 22 MHz and other observations at 38 MHz are 3500°K (+1900°, −1400°) and 5700°K (+1000°, −2000°), respectively. These temperatures will be less than the density-weighted, mean electron temperatures. Good agreement is found with electron temperatures for these regions derived from measurements of hydrogen recombination lines. The proportion of nonthermal emission originating on the near side of IC 1805 is equivalent to an arm−interarm mean emissivity of $9.1\ (\pm 1.7) \times 10^{-41}$ W m$^{-3}$ Hz$^{-1}$ sterad$^{-1}$ at 22 MHz. The ratio of foreground-to-background, nonthermal emission is slightly greater than the corresponding ratio of 21-cm, atomic-hydrogen emission from the same direction. (auth)

**20607** ABUNDANCES IN DIFFUSE NEBULAE. Rubin, Robert H. (National Radio Astronomy Observatory, Green Bank, W. Va.). Astrophys. J., 155: 841-51(Mar. 1969).

A scheme for determining nebular abundances is presented that allows for temperature variations in a nebula along the line of sight. It is demonstrated that neglect of temperature fluctuations, for certain conditions of excitation, can cause significant underestimates of the abundances of oxygen, nitrogen, and neon with respect to that of hydrogen. For a wide range of excitation conditions, reliable abundance ratios of neon and nitrogen relative to oxygen, and neon and oxygen relative to helium may be obtained even when these abundances cannot be obtained relative to hydrogen. The determination of abundances of neon and nitrogen with respect to that of oxygen is also not very sensitive to temperature variations in the nebula. Recent observations are used in conjunction with improved atomic parameters to obtain abundances for some of the brightest H(II) regions. These abundances have been corrected, where the observations permit, for changes in the electron temperature along the path of observation through the nebula. (auth)

**20608** THE RADIO NEBULA NRAO 591/593. Hughes, V. A.; Butler, R. (Queen's Univ., Kingston, Ont.). Astrophys. J., 155: 1061-76(Mar. 1969).

The radio nebula NRAO 591/593 which appeared to consist of an association of a thermal and nonthermal source, similar to W49, was observed and analyzed in detail. Models were developed for H(II) regions, based on a Gaussian distribution of electron density. The distance was determined by use of the Maryland−Green Bank 21-Cm Survey. There is no evidence that either of the principal sources is nonthermal, and the physical parameters of the region are derived for comparison with other large H(II) regions. NRAO 591 contains a small-diameter source with high cutoff frequency, of the type that has been classified as a compact region with high emission measure, but an alternative suggestion is made that compact regions could be nonthermal and could be evidence for the evolution of protostars. Both principal components of the nebula lie below the galactic equator in a region where H(I) and continuum observations show that the plane is distorted upward. (auth)

**20609** SOME MODELS OF THE EMISSION-LINE REGION OF 3C 273. Bahcall, John N.; Kozlovsky, Ben-Zion (California Inst. of Tech., Pasadena). Astrophys. J., 155: 1077-97 (Mar. 1969).

Models for the emission-line region of 3C 273 are derived by using ionization distributions calculated with extrapolated forms of the observed photon flux. The calculated ionization distributions, which are different from those assumed by previous workers, are used to make estimates of the relative abundances of H, He, O, Ne, Mg, and Fe. Estimates are also given of the physical parameters that characterize the emission-line region. (auth)

**20610** STRUCTURE OF QUASI-STELLAR RADIO SOURCES. Hogg, David E. (National Radio Astronomy Observatory, Green Bank, W. Va.). Astrophys. J., 155: 1099-1111(Mar. 1969).

Interferometric observations at a frequency of 2695 MHz were made of 21 quasi-stellar radio sources, of which nineteen were resolved at the spacing of 16,200 wavelengths. Positions were determined for those sources which are not too heavily resolved, and it was found that in most cases the centroid of the radio emission lies near the optical object. Only two of the resolved sources have radio components which coincide with the blue stellar object. It is shown that the quasi-stellar sources which are large in angular extent have steep radio spectral indices. The positions and models of brightness distribution are given for fourteen other sources which have been suggested as possible quasi-stellar sources. (auth)

**20611** OPTICAL POLARIZATION OF THREE QUASI-STELLAR OBJECTS. Liller, William (Harvard Coll. Observatory, Cambridge, Mass.). Astrophys. J., 155: 1113-15(Mar. 1969).

Consideration of all known optical polarization data on 3C 273 leads to the conclusion that this QSO may indeed exhibit variable polarization. 3C 48 and 3C 286 show no detectable optical polarization. (auth)

**20612** MICROWAVE DETECTION OF INTERSTELLAR FORMALDEHYDE. Snyder, Lewis E. (National Radio Astronomy Observatory, Green Bank, W. Va.); Buhl, David; Zuckerman, B.; Palmer, Patrick. Phys. Rev. Lett., 22: 679-81(Mar. 31, 1969).

Interstellar formaldehyde ($H_2CO$) has been detected in absorption against numerous galactic and extragalactic radio sources by means of the $1_{11}-1_{10}$ ground-state rotational transition at 4830 MHz. The absorbing regions often correspond in velocity with 18-cm OH features. $H_2CO$ is the first organic polyatomic molecule ever detected in the interstellar medium and its widespread distribution indicates that processes of interstellar chemical evolution may be much more complex than previously assumed. (auth)

**20613** TELEVISION DETECTION OF THE CRAB NEBULA PULSAR. Miller, J. S. (Univ. of California, Santa Cruz). Nature (London), 221: 1037-8(Mar. 15, 1969).

Strong optical pulses have been reported as occurring in the Crab Nebula, with a period in good agreement with that found for the pulsar NP 0532. These observations were obtained with a conventional photoelectric photometer, the output of which was recorded on a multiscaler analyzer operating at or near the period of the radio pulses. In order to determine more accurately the position of the optical flashes a study was made using a television camera with an image intensifier coupled to a camera tube, the camera being placed at the coudé focus of the 120-inch Santa Cruz telescope. The observations were made on Feb. 3, 1969, and the mode of operation of the equipment is described. The output was simultaneously fed into a television monitor and video tape recorder; two pictures are reproduced. From the results it was concluded that the optical source is in the vicinity of the south−west component of a double star near the centre of the Nebula, a star suspected as being a remnant of the supernova explosion that produced the Nebula; this confirmed the earlier reports. It was estimated that the ratio of maximum and minimum intensities was at least 50. (UK)

**20614** FREQUENCY OF EVENTS PRODUCING PULSARS. Trimble, V. (Smith Coll., Northampton, Mass.). Nature (London), 221: 1038(Mar. 15, 1969).

It is stated that, if the pulsar observed near the Crab Nebula is a remnant of the supernova event of 1054, then the secular change in its period can be used to estimate the age of typical longer-period pulsars and hence, the frequency with which pulsar-producing events occur in the Galaxy. The period of the Crab pulsar is changing at about $1.35 \times 10^{-5}$ sec/yr. Rates of change for longer-period pulsars are, at the most, of the order of $10^{-7}$ sec/yr. This means that the rate of period change must be a decreasing function of time if the Crab type of object is to evolve into the latter type. If it is assumed that the rate of period change is a linearly decreasing function of time then the measured rates and upper limits suffice to determine a lower limit of $2 \times 10^5$ yr. for the age of a 1.5 sec period pulsar. About 20 pulsars have been observed within about 500 pc from the Sun. The region thus surveyed is about 1/400 or 1/6000 of the volume of the Galaxy, depending on whether the objects belong to the disk or the halo population. It may then be deduced that the total number of pulsars in the Galaxy is of the order of 16,000 or 240,000, depending on the population type. Combining these numbers with the lower limit for the age of representative objects suggests an upper limit for pulsar-producing events in the Galaxy of one every 12 yr for disk objects or one per year for halo objects. The former

number is in reasonable agreement with supernovae rates, and if the present pulsar population is representative of that over the lifetime of the Galaxy, then the total number of pulsars created over that lifetime has been at the most $5 \times 10^8$ or $10^{10}$. It is suggested that it is the rate of stored energy loss from a pulsar which is a decreasing function of time. A typical pulsar with period 1.5 sec., and changing at $10^{-7}$ sec/yr, will have an age of at most $7 \times 10^8$ yr, and loses energy at a rate of $10^{32}$ ergs/sec.. which is ample to supply the observed radiation from longer-period pulsars if they are at distances <1 kpc. The rate of pulsar-producing events required to maintain the present density of objects in space with such lifetimes is 1 per 400,000 yr for a disk population or 1 per 30,000 yr for a halo population, and the total number of pulsating sources created over the history of the Galaxy is at most 25,000 or 300,000 for the two population types if their density in space has remained constant. (UK)

**20615** PULSARS AND ANCIENT CHINESE RECORDS OF SUPERNOVA EXPLOSIONS. Shen, C. S. (Purdue Univ., Lafayette, Ind.). Nature (London), 221: 1039-40(Mar. 15, 1969).

The discovery of a pulsar near the Crab Nebula with an apparently increasing period of 0.03309 sec. and the earlier detection of another short-period pulsar (PSR 0833-45) at the site of the supernova remnant Vela X appear to support the idea that pulsars are associated with the end product of supernova explosions, and presumably with neutron stars. The rate of pulsation is fastest when the star is young, but gradually slows down to ~1 sec. With a view to testing such a hypothesis it was interesting to look for more pulsars associated with supernovae of known age, and examination of ancient oriental records of suspected supernovae events suggested some promising candidates. The most promising candidate is the supernova of AD 1006, a description of which is given and comparison made with the Crab. Other events discussed include those of AD 185, AD 396, AD 437, and AD 902.(UK)

**20616** HIGH-RESOLUTION OBSERVATIONS OF THE RADIO SOURCE W49. Wynn-Williams, C. G. (Cambridge Univ., Eng.). Mon. Notic. Roy. Astron. Soc., 142: 453-64(1969).

Observations of the galactic radio source W49 (3C 398) were made with the Cambridge One Mile Radio Telescope, with beam-widths of 23″ × 148″ at 1407 MHz and 80″ × 510″ at 408 MHz. The thermal component is more compact than was previously thought, having a bright region with a complicated double structure whose main peaks correspond closely with the regions of OH emission, and a feature of lower brightness which extends towards the non-thermal component; the electron temperature of the bright region has the unusually high value of 14,000 ± 3000°K. The structure of the nonthermal component, a supernova remnant, displays a remarkable variation with frequency, which is probably associated with the presence of the nearby H II region and may involve directed emission. (auth) (UK)

**20617** MODERN PROBLEMS OF RELATIVISTIC ASTROPHYSICS. Braccesi, A. (Univ., Bologna). Nuovo Cim., Suppl., 6: 971-89(1968). (In Italian).

The phenomenology of quasars is presented, leaving the question about the nature of their red shift open. Typical spectra are given to illustrate their spectral morphology. (J.S.R.)

**20618** A 1417-MHz SEARCH FOR RADIO SOURCES HAVING A FLUX EXCESS AT SHORT WAVELENGTHS. Davis, M. M. (Netherlands Foundation for Radio Astronomy and Observatory, Leiden). Bull. Astron. Inst. Neth., 19: 201-26(1967).

A systematic survey at 1417 MHz (21.2 cm) covered 3.7 steradians of the sky in search of discrete sources missed by surveys at longer wavelengths. The 25-meter Dwingeloo telescope was used with switched beams and a parametric amplifier. The survey is complete to $2.3 \times 10^{-28}$ watts $\cdot m^{-2} \cdot Hz^{-1}$ away from the galactic plane and the North Polar Spur. This limit is set by irregularities in the background radiation. The 300-foot Green Bank telescope was used to confirm the 188 sources listed in table 6, of which 69 have not previously been catalogued. One-hundred-ninety-four previously catalogued sources found in Dwingeloo but not observed in Green Bank are not included in the table. (auth)

**20619** SPECTROSCOPY OF A NEW, FAINT QUASI-STELLAR OBJECT. Stockton, Alan (Univ. of Hawaii, Honolulu, Kitt Peak National Observatory, Tucson, Ariz.). Astrophys. J., 155: L141-2(Mar. 1969).

Spectroscopic observations of a faint quasi-stellar object found near the peculiar double galaxy NGC 3561 are presented. Probable changes in the structure of the Ly-$\alpha$ emission were detected. (auth)

**20620** DIFFUSE X-RADIATION SPECTRUM BELOW 4 keV. Baxter, A. J.; Wilson, B. G.; Green, D. W. (Univ. of Calgary, Alberta). Astrophys. J., 155: L145-8(Mar. 1969).

More detailed evaluation of the diffuse x radiation reported earlier by the authors gives a revised spectrum of $15E^{-1.48}$ for $2 < E < 10$ keV. New measurements between 0.20 and 4.0 keV on October 8, 1968, show a spectrum above 1 keV consistent with an $E^{-1.5}$ form, but below 1 keV the flux increases rapidly to the lowest energies measured. The estimated flux at 0.27 keV was 2160 ± 170 photons $cm^{-2}$ $sec^{-1}$ $sterad^{-1}$ $keV^{-1}$. No significant change in the low-energy flux was observed between the galactic pole and the galactic plane in the direction of Cassiopeia. (auth)

**20621** FURTHER SPECTROSCOPIC OBSERVATIONS OF THE OPTICAL OBJECT IDENTIFIED WITH X-RAY SOURCE CYGNUS X-2. Kraft, Robert P.; Miller, Joseph S. (Univ. of California, Santa Cruz). Astrophys. J., 155: L159-61(Mar. 1969).

Spectroscopic observations of the fifteenth-magnitude star identified with the x-ray source Cyg X-2 were obtained between June 27 and July 1, 1968. These supplement the optical radial-velocity results of Oct. 6–8, 1967 (Kraft and Demoulin 1967), which provided an inconclusive test of the proposition that Cyg X-2 is a binary star. The conventional procedure of trailing the image several times over the slit in the course of a single exposure was adopted. (W.D.M.)

**20622** UPPER LIMIT TO THE ABUNDANCE OF $^3$He IN MESSIER 17. Seling, T. V. (Univ. of Michigan, Ann Arbor); Heiles, C. Astrophys. J., 155: L163-6(Mar. 1969).

The results of an attempt to detect the 8665.650-MHz hyperfine-transition line of $^3$He II are reported, and an upper limit of $[^3H]/[H] \simeq 4 \times 10^{-5}$ is deduced. (auth)

**20623** OPTICAL FLASHES FROM THE CRAB NEBULA M1. Willstrop, R. V. (Univ. of Cambridge, Eng.). Nature (London), 221: 1023-5(Mar. 15, 1969).

Plots of the color indices, with their uncertainties, are given. It is concluded that, if systematic errors are absent or small enough not to add significantly to these considerable uncertainties, the visible light of the pulsar is reddish, although the results are not inconsistent with the G-type distribution already reported. Nevertheless, the object has an ultraviolet excess. (W.D.M.)

**20624** EAST–WEST LINEAR POLARIZATION DISTRIBUTIONS OF RADIO GALAXIES AT 1418 MHz. Seielstad, G. A.; Weiler, K. W. (California Inst. of Tech., Pasadena). Astrophys. J., 18: Suppl. Ser. 158, 85-126(Mar. 1969).

The distributions along a circle of constant declination of the linearly polarized radiation at a frequency of 1418 MHz from sixty-eight extragalactic radio sources were examined. The effective resolution was ~0.8′. At places within many sources very high degrees of polarization (>15%), usually accompanied by a constant plane of polarization, were found. Both facts imply the existence of a highly ordered magnetic field. Often other regions within the same source also contained a uniform field, but oriented differently. Less frequently the field is well ordered over an entire component or even over the entire source. These regions of uniformity can exceed galactic dimensions (~100 kpc). The distributions of linearly polarized and total radiation, obtained at nearly the same frequency with identical resolution, were compared. In general, the two distributions bear little resemblance; one certainly cannot predict the distribution of linearly polarized radiation from a knowledge of the distribution of total radiation. An important exception is the class of core–halo sources. For these, most of the linearly polarized radiation, at least at decimetric wavelengths, originates in the halo. The cores have a very low degree of polarization, except possibly at short centimetric wavelengths. Because the polarization distributions in many cases are broader than the total distributions, it is suggested that halos about radio sources may occur more commonly than supposed. For the identified objects distinctive polarization properties were sought among the various optical classes. It appears that cD galaxies either have unusually low integrated degrees of polarization or atypical dependences of polarization parameters on wavelength. The other optical classes appear indistinguishable on the basis of their linear polarization properties. It is suggested that depolarization occurs largely within the sources themselves. It is proposed that emission and Faraday rotation occur together within the source components but that only emission occurs in the outskirts. (auth)

**20625** ON THE EXISTENCE OF THE GALACTIC RADIO HALO. Anand, K. C.; Daniel, R. R.; Stephens, S. A. (Tata Inst. of Fundamental Research, Bombay). Proc. Indian Acad. Sci., Sect. A, 68: 219-27(Nov. 1968).

Radio-astronomical data available on the galactic background radiation were carefully examined to deduce information on the existence of a galactic radio halo. It is shown that, although considerable doubt has been recently expressed by some regarding its existence, no convincing and quantitative reasoning has been

so far advanced towards this; on the other hand, there are substantial arguments in its favor. (auth)

## Solar Phenomena

*Refer also to abstracts 20733, 20763, 20764, and 20816.*

**20626** (N-68-25687) ON THE ACCELERATION MECHANISM OF PLASMA OUTFLOW FROM THE SUN. Konyukov, M. V. Translated from a Russian paper. 32p. CFSTI.

The problem dealt with in this paper consists in finding a mechanism of plasma acceleration up to energies prevailing in the region of Earth's orbit. Its selection is based upon the results of quantitative analysis of very simple models of plasma flow from the Sun, provided they meet a series of conditions relative to relationships between solar corona and interplanetary plasma; here laminar conditions of the flux intervene, which allow the fulfilment of the gasdynamics approximation. Several models are discussed, and within the model utilized it is assumed that the energy for the acceleration of coronal plasma is supplied by a heat source emerging as a result of dissipation of mechanical motions. (auth) (STAR)

**20627** TIME SPLITTING OF SOLAR RADIO BURSTS. Elgaroey, Oe. (Inst. of Theoretical Astrophysics, Oslo). Astrophys. Lett., 3: 39-42(Feb. 1969).

Solar radio bursts often occur in pairs. It is suggested that this splitting in time may result from propagation via two different magneto-ionic modes. (auth)

**20628** HIGH-RESOLUTION BALLOON SPECTRA OF THE SUN IN THE MgII DOUBLET LINES. II. Lemaire, P. (CNRS, Verrieres-le-Buisson, France). Astrophys. Lett., 3: 43-8(Feb. 1969).

Balloon spectra of the Sun from 2770 to 2845 Å with spatial resolution on the disk of 10 arc sec were obtained during the partial eclipse of September 22, 1968, from Aire sur l'Adour, France. The spectral resolution achieved was 45 mÅ. Measurements of the center-to-limb variation of the ionized magnesium lines (2795.523 Å and 2802.698 Å) profile are shown. The influence of chromospheric activity is clearly evidenced on the emission peaks of the Mg II doublet. (auth)

**20629** STOCHASTIC ASPECTS OF MAGNETIC LINES OF FORCE WITH APPLICATION TO COSMIC RAY PROPAGATION. Jokipii, J. R.; Parker, E. N. (Univ. of Chicago). Astrophys. J., 155: 777-98(Mar. 1969).

It is pointed out that magnetic lines of force in nature are generally stochastic and ergodic. Owing to unavoidable fluctuations in the field, adjacent lines of force random-walk away from each other. The stochastic properties of the lines of force in the Universe are related to the stochastic properties of the (turbulent) velocity fields in which they are imbedded. The consequent random walk of the field lines is shown to contribute appreciably to $K_\perp$, the coefficient for particle diffusion normal to the average field, with the result that the particles are spread across the average magnetic field much more rapidly than expected from the usual resonant scattering by small-scale irregularities. The Sun's extended magnetic field, traversed by both energetic solar particles and galactic cosmic rays, serves as an excellent illustration of these concepts. Application of the theory to the interplanetary magnetic fields shows that the random walk of the field lines is determined by the observed power spectrum of the fluctuations in the magnetic field at zero frequency. The observed turbulent velocity field in the solar protosphere yields a random walk equal to that obtained from the observed power spectrum of the magnetic field. These two determinations of the random walk of the field lines, in turn, agree with the observed spread in solar longitude of promptly arriving solar cosmic rays. The observed shear planes and flux tubes of the "wet spaghetti" model of the interplanetary magnetic field are evidently a direct manifestation of the photospheric supergranulation. The diffusion of cosmic rays in the interplanetary magnetic field observed near solar minimum is also discussed. For protons with energies of 10 MeV and below, the ratio $K_\perp/K_\parallel$ at the orbit of the Earth becomes comparable to unity, instead of nearly zero as would be expected on the basis of resonant scattering alone. The contribution of the random walk to $K_\perp$ is also significant at relativistic energies. Application to the theory of the diurnal variation of galactic cosmic rays agrees with observation both at ~10 MeV and at relativistic particle energies. (auth)

**20630** STUDIES IN STELLAR EVOLUTION. VII. SOLAR MODELS. Torres-Peimbert, S.; Simpson, E.; Ulrich, R. K. (Univ. of California, Berkeley). Astrophys. J., 155: 957-64 (Mar. 1969).

The Berkeley stellar-evolution program was used to compute evolutionary sequences in an attempt to establish a solar model. The chemical composition and mixing length were varied to obtain the luminosity and temperature of the Sun for ages ranging from 4.5 to $5.0 \times 10^9$ years. The models included the cross-section for the $H^1(p,e^+\nu)H^2$ reaction, $S(0) = 3.78 \times 10^{-25}$ MeV barns. A comparison of the models with spectroscopic observations suggests that the primordial solar composition lies between X = 0.775, Z = 0.015, and X = 0.730, Z = 0.025. However, the solar-neutrino observations can be explained only with a solar metal content Z < 0.02. (auth)

**20631** CORONAL BRIGHTNESS AT 2.23 MICRONS. Peterson, Alan W. (Univ. of New Mexico, Albuquerque). Astrophys. J., 155: 1009-15(Mar. 1969).

Infrared observations of the corona during the November 12, 1966, eclipse reveal the presence of a sharp, thermal-emission zone at 3.9 $R_\odot$ where calculations predict interplanetary dust is undergoing rapid vaporization. A rounded emission zone with no sharp inner edge appears at 3.3 $R_\odot$ where, presumably, dust in elliptical orbits is undergoing less rapid vaporization. These observations add a new component to the coronal radiation field, i.e., interplanetary dust emission. The thermal emission is found to contribute to coronal reddening but, in addition, it is found that diffraction must also contribute to the observed reddening. Sufficient spectral data are not yet available to specify the dust-vaporization temperature more precisely than earlier estimates of 800 to 2000°K. (auth)

**20632** ROCKET AND SATELLITE STUDIES OF THE X-RAY EMISSION FROM THE QUIESCENT SUN. Sengupta, P. R. (Univ. of Iowa, Iowa City). Contract NAS5-9076. Proc. Iowa Acad. Sci., 75: 268-84(1968).

Quiescent Sun x-ray measurements made by different workers during the past 19 years were studied. Analysis of the data available up to April 1967, confirms the conclusion that the quiescent Sun x-ray emission is thermal in nature and is closely related to the solar activity level. The spectrum below 18 Å is mainly continuous and is primarily due to recombination emission. Bremsstrahlung becomes important at high temperatures. The 18 to 100 Å flux is primarily due to line emission and is emitted mainly by the undisturbed coronal regions. Below 20 Å the emission is primarily from the active—hotter and denser—coronal regions. In this spectral region the flux varies within wide limits, depending on the number, dimensions, density, and temperature of the active regions. Preferred regions of x-ray emission lie above strong calcium plages in the chromosphere and coincide with regions of enhanced centimeter radio emission. Seventy-five percent of the total x-ray flux comes from these regions. The existing theory is capable of predicting x-ray flux within a factor of 2 or 3, using solar radio spectroheliograms in the centimeter range. (auth)

**20633** MODERN PROBLEMS OF SOLAR RADIOASTRONOMY. Noci, G. (Osservatoiro Astrofisico di Arcetri, Florence). Nuovo Cim., Suppl., 6: 835-56(1968). (In Italian).

Solar radio emissions are grouped substantially into three categories: radio bursts, slowly variable components, and radio emissions of the quiet Sun. The theoretical and experimental observations made during the last few years in each of the categories are reviewed and analyzed. (J.S.R.)

**20634** MICROSCALE FLUCTUATIONS IN THE INTERPLANETARY MAGNETIC FIELD. Burlaga, L. F.; Ogilvie, K. W.; Fairfield, D. H. (Goddard Space Flight Center, Greenbelt, Md.). Astrophys. J., 155: L171-5(Mar. 1969).

Results of simultaneous measurements of the interplanetary plasma and magnetic field, obtained during 1967 by Explorer 34, are presented. Results show that microscale magnetic-field fluctuations are governed by the local balance between the proton thermal energy density and the magnetic-field energy density. (W.D.M.)

**20635** PLASMA EMISSION FROM THE SUN WITH THERMAL CONDUCTIVITY PLAYING A SIGNIFICANT ROLE. Konyukov, M. V. (Lebedev Inst. of Physics, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 489-95(1968).

Translated from Geomagn. Aeron., 8: 609-17(1968).

The properties of a plasma emitted from the Sun in the presence of a three-dimensional heat source and with electronic thermal conductivity playing a significant role are investigated. It is shown that sourceless emission can be studied only for small regions of direct heating. An analysis of the properties of the solutions realized indicates that the emission of a plasma from the sun cannot be described without taking viscosity into account. (auth)

**20636** VELOCITY AND WIDTH OF INTERPLANETARY PLASMA FLOWS AT VARIOUS MERIDIONAL DISTANCES FROM

THE CENTERS OF ACTIVE REGIONS. Ivanov, K. G.; Mikerina, N. V. (Inst. of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 617-18(1968).

Translated from Geomagn. Aeron., 8: 776-7(1968).

An analysis of the results of plasma measurements in interplanetary space shows the complex distribution of the directional velocity of flows from active regions of the solar atmosphere. The distribution is very irregular, both in the radial and longitudinal directions. It is assumed that the velocity distribution is also irregular in the meridional direction. This assumption is confirmed here on the basis of an investigation of the dependence of the maximum observed velocities, on the difference in the heliographic latitudes of a spacecraft, and the center of the active region. (W.D.M.)

**20637** QUASI-PERIODIC INTENSITY VARIATIONS OF RADIO EMISSION FROM THE SUN AT 3.3-cm WAVELENGTH. Durasova, M. S.; Lavrinov, G. A.; Chandaev, A. K.; Yudin, O. I. (Gorky State Univ., USSR). Izv. Vyssh. Ucheb. Zaved., Radiofiz., 11: 1782-90(1968). (In Russian).

The results of an experimental study of radiation flux fluctuations from the Sun are presented. The correlation functions and recording spectra referring to quiet and active Sun are investigated. Quasi-periodic changes of the flux with the periods of about 250 and 700 sec are discovered. The intensity changes in a maximum of the spectrum correlate with the variations of the solar activity. A possible relation between the observed phenomena and other occurrences in the solar atmosphere periodical motions is discussed. (auth)

**20638** A HIGH RESOLUTION SPECTRAL ANALYSIS OF DAILY RELATIVE SUNSPOT NUMBER AND 10 . 7 CM SOLAR FLUX. Bhargava, B. N. (Colaba Observatory, Bombay). Proc. Indian Acad. Sci., Sect. A, 68: 265-72(Nov. 1968).

Auto and cross spectra of relative sunspot number and the slowly varying component of solar radiation at 10.7 cm were computed for a 52-month period beginning September 1, 1958. Significant features of the spectra are relatively high variance at periods corresponding to one, three, and four solar rotations. Statistically significant spectral peaks were observed at three other frequencies and are ascribed to amplitude modulation of the 27-day component. The cross-spectral analysis indicates that, during the period under investigation, the solar 10.7 cm flux leads the sunspot number for periods in excess of about 27.7 days; for shorter periods the flux lags behind the sunspot number. The coherence between the two time series, after an initial decrease from unity at zero frequency, assumes a maximum value of 0.985 at 27.7 days. The phase and coherence indicate that long-lived radio-emission regions and spots appeared to corotate during 1958–62 with a period of 27.7 days. (auth)

**20639** RELATIVE RADIO FLUXES AT WAVELENGTHS OF 2 AND 3.2 CM FROM ACTIVE REGIONS ON THE SUN. Rzhaksinskii, F. K. Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 740-1(1968).

Translated from Geomagn. Aeron., 8: 927-8(1968).

The results of determinations of the slope of the spectral characteristic of individual radio sources from measurements of the location of the effective center of solar radio emission at $\lambda = 2$ and 3 cm are presented. (W.D.M.)

**20640** AUTOCORRELATION OF SOLAR ACTIVITY. Gabrovski, Iv.; Gadzhokov, V.; Kalinkov, M. (Astronomy Section, Sofia). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 742-5(1968).

Translated from Geomagn. Aeron., 8: 929-32(1968).

It is of some interest to compute the autocorrelation functions of various solar activity indexes. The results of computations of the autocorrelation functions of sunspots (Wolf numbers) and of the sunspot area are reported. (W.D.M.)

## Galaxies

*Refer also to abstracts 20652 and 20725.*

**20641** THE INTERACTION OF THE METAGALACTIC ULTRAVIOLET BACKGROUND RADIATION WITH GALAXIES AND THE LIMIT ON THE DENSITY OF THE INTERGALACTIC GAS. Sunyaev, R. A. (Inst. of Applied Mathematics, Moscow). Astrophys. Lett., 3: 33-8(Feb. 1969).

The observed distribution of neutral hydrogen in the peripheries of galaxies is only compatible with the metagalactic background of ionizing ultraviolet radiation when the latter is smaller than $10^{-23}$ cm$^{-2}$ erg (sec ster Hz)$^{-1}$ at $\lambda < 912$ Å. This contradicts the hypothesis of the existence of an intergalactic gas as hot as $T > 10^{5}$K with a density of the order of critical density ($n \approx 10^{-5}$ cm$^{-3}$), since such gas must radiate strongly in the ultraviolet. (auth)

**20642** ON THE SPIRAL STRUCTURE OF DISK GALAXIES. III. COMPARISON WITH OBSERVATIONS. Lin, C. C. (Massachusetts Inst. of Tech., Cambridge); Yuan, C.; Shu, Frank H. Astrophys. J., 155: 721-46(Mar. 1969).

The density-wave theory of galactic spirals is developed in a form slightly more general than that outlined by Lin and Shu in an earlier short communication. Only self-sustained waves are studied and the problem of the origin of the spiral structure is barely discussed. The implications of the theory are examined, both in general terms and in detail. The conclusions are compared with observations. Specifically, (1) the distribution of atomic hydrogen in the Galaxy, (2) the systematic motion of the gas, (3) the distribution of young stars and other optical objects, and (4) the migration of moderately young stars are considered. Good agreements are obtained in all cases if a pattern speed of about 13 km sec$^{-1}$ kpc$^{-1}$, and a spiral gravitational field equal to about 5% of the symmetrical field are adopted. General discussions are also given on (a) the structure of the magnetic field and its role on the systematic motion of the gas, (b) the role of the density wave in the process of star formation, and (c) the distribution of H(II) regions as revealed by the 109a radio observations. (auth)

**20643** DYNAMICS OF THE BENDING OF THE GALAXY. Hunter, C.; Toomre, Alar (Massachusetts Inst. of Tech., Cambridge). Astrophys. J., 155: 747-76(Mar. 1969).

A mathematical theory describing infinitesimal bending oscillations and/or responses of very thin rotating disks of self-gravitating material is developed. This theory is applied in detail to two representative families of thin-disk models, and many possible bending eigenmodes are found. It is also shown, however, that the frequency spectrum of such oscillations is not necessarily discrete; on the contrary, for any disk whose density tapers sufficiently gradually to zero near its edge, that spectrum is at least partly continuous, and the corresponding long-term response to transient forcing is dispersive. The results of this study argue against certain proposed explanations of the observed warp of the "plane" of this Galaxy. Those include primordial free oscillations and any tidal forcing from the Magellanic Clouds at more or less their present distance. The hypothesis most favored by the analyses is that at least the Large Cloud passed within a distance of the order of 20 kpc of the galactic center approximately $5 \times 10^{8}$ years ago, and that the present warp evolved from the tidal distortion established during that era. Even with so close an approach, however, a mass of at least $2 \times 10^{10}$ $M_{\odot}$ seems required of the LMC. (auth)

**20644** MAGNETIC FIELDS IN INTERSTELLAR NEUTRAL-HYDROGEN CLOUDS. Verschuur, G. L. (National Radio Astronomy Observatory, Green Bank, W. Va.). Astrophys. J., 155: L155-8(Mar. 1969).

The fields of tens of microgauss detected in two neutral-hydrogen clouds may not represent the interstellar magnetic-field strength but may instead be the result of field amplification in contracting gas clouds. (auth)

**20645** COSMIC-RAY HEATING OF THE INTERSTELLAR GAS. Field, G. B.; Goldsmith, D. W.; Habing, H. J. (Univ. of California, Berkeley). Astrophys. J., 155: L149-54(Mar. 1969).

A model of the interstellar medium is presented based on detailed calculations of heating by low-energy cosmic rays. The model contains two thermally stable gas phases that coexist in pressure equilibrium, one at $T = 10^{4}$°K and one at $T < 300$°K. The hot gas occupies most of interstellar space. Gravitation in the z-direction compresses about 75% of the gas into the cool, dense phase to form clouds. By choosing three parameters (the cosmic-ray ionization rate, the amount by which trace elements are depleted in sticking to dust grains, and the magnetic-field strength), six previously unrelated observational parameters are predicted to within a factor of 2. (auth)

**20646** DETECTION OF X-RAYS FROM THE LARGE MAGELLANIC CLOUD. Mark, Hans; Price, R.; Rodrigues, R.; Seward, F. D.; Swift, C. D. (Univ. of California, Livermore). Astrophys. J., 155: L143-4(Mar. 1969).

A source of low-energy x rays approximately 12° wide was detected at the position of the Large Magellanic Cloud. Between 1.5 and 10.5 keV the spectrum is slightly softer than that of the isotropic background. The observed flux corresponds to an emission rate of about $4 \times 10^{38}$ ergs sec$^{-1}$. (auth)

**20647** COMPARISON OF THE NUCLEI IN M51 AND NGC 4151. Weedman, Daniel W. (Univ. of Texas, Austin). Astrophys. J., 155: L129-31(Mar. 1969).

Observations of the nuclear sizes, emission-line widths, and densities in the Sc galaxy M51 and the Seyfert galaxy NGC 4151 show that the nuclei are similar in many respects. It is concluded

that the only basic difference between the two nuclei is the presence of a source of ionizing energy in NGC 4151 that is $10^3$ times as intense as the source in M51. (auth)

**20648** PROGRAM FOR COMPUTING PROBABILITY DENSITY. Gaivoronskaya, T. V. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 774-6(1968).

Translated from Geomagn. Aeron., 8: 964-5(1968).

There is some interest in the statistical analysis of the extensive data obtained in recent years from ionospheric observations at the global network of stations. The initial data of the problem are the deviations $x = (f-M_e)\ M_e \cdot 100\%$ of the critical F2-layer frequencies from the median values computed from observations over 31 days for each hour. The distribution density of the x values was computed on a BESM-3M computer. (W.D.M.)

## Cosmology

**20649** VARIATIONS IN THE PRIMEVAL HELIUM ABUNDANCE. Harrison, E. R. (Univ. of Massachusetts, Amherst). Astron. J., 73: 533-4(Sept. 1968).

Earlier studies indicated that the helium produced in the early stages of the Universe has a relative abundance by mass of $Y_9 \simeq 0.25$, and that the primeval helium produced by fireball nucleosynthesis has everywhere the same abundance. The helium abundance in the Sun, in main sequence O and B stars, and in various gaseous nebulae is in rough agreement with the calculated value of $Y_9$, and lends support to the idea that the original abundance of helium is uniform. Recent observations suggest, however, that the primeval helium abundance might vary from place to place. The weakness of the helium lines in the spectra of blue horizontal-branch stars of globular clusters and old halo B stars reveals an abnormally low helium abundance in their surface layers. In a consideration of the possibility that the primeval helium abundance is not uniform, it is shown that, in this event, the big bang cosmologies are not in need of drastic revision. It is then possible that the variations in the primeval helium abundance are in fact an extremely useful source of information of the spatial variations of matter at the time of helium synthesis, and of the early stages of galaxy formation. There may exist a correlation between helium abundance and stellar populations. The helium-deficient halo Population II stars are formed in the outer zones of lower density, and perhaps their early phases are protracted and complicated because of deuterium burning. The Population I stars, particularly near the nuclear region, are formed out of material from the inner zones of greater density and their helium abundance is therefore higher. (BBB)

**20650** NONTHERMAL INTERGALACTIC BREMSSTRAHLUNG AND THE DIFFUSE X-RAY BACKGROUND. Silk, J. (Inst. of Theoretical Astronomy, Cambridge, Eng.); McCray, R. Astrophys. Lett., 3: 59-64(Feb. 1969).

Isotropic x-ray background in the range 1 keV to 1 MeV is interpreted as bremsstrahlung by a distribution of subcosmic (1 keV to 10 MeV) electrons interacting with a low-density ($10^{-7}$ atoms $cm^{-3}$), thermal, ionized intergalactic medium in an expanding universe. The energy density of intergalactic electrons required at present to produce the observed x rays is $10^{-4}$ eV $cm^{-3}$, if the electrons were injected by a burst at a red shift of about 10 and were relaxed by cosmological expansion and Coulomb interactions with the ionized medium. (auth)

**20651** MATTER AND EXPANSION OF THE UNIVERSE. Onicescu, Octav. Rend. Semin. Mat. Fis. Milano, 38: 112-24(1968). (In Italian).

The principles are given of an extension of Newtonian mechanics denominated "invariantive mechanics," the inertial aspect of which gives, for a unique material point in movement, the Einsteinian expression of the mass and of the proper energy and, for a system, to the interpretations of gravitation and of Hubble's dilatation. (auth)

**20652** TWO PROBLEMS IN GRAVITATION. II. Rood, Herbert J. (Wesleyan Univ., Middletown, Conn.). Sky Telesc., 37: 225-7(Apr. 1969).

The "number mass" of a cluster of galaxies is habitually 10 or more times smaller than the "virial-theorem mass." This discrepancy, which constitutes one of the outstanding unsolved problems of astronomy, is discussed in some detail. (W.D.M.)

**20653** ON THE HAMILTONIAN FORM OF THE EINSTEIN THEORY OF GRAVITATION. Udeschini, Paolo (Univ., Milan). Rend. Semin. Mat. Fis. Milano, 38: 52-76(1968). (In Italian).

Some considerations are given on the generalized Hamiltonian form of the equations of motion, when primary and secondary constraints occur. The theory of a space–time physical field is recalled, with particular reference to Einstein's theory of gravitation. After putting Einstein's field equations in the Lagrangian form, Hamiltonian form is considered, which involves the basic concept of a physical state at a given time. This means, in a riemannian space–time, a state on a certain three dimensional space-like surface. By choosing suitable dynamical variables (of which a geometrical interpretation is given) and taking into account the primary constraints, the Hamiltonian function is then built, following Dirac's method. (auth)

**20654** THE POST-NEWTONIAN EQUATIONS OF HYDRODYNAMICS IN THE BRANS–DICKE THEORY. Nutku, Yavuz (Univ. of Chicago). Contract Nonr-2121(24). Astrophys. J., 155: 999-1007(Mar. 1969).

The equations of hydrodynamics and the resulting conservation laws are derived for a nonviscous fluid, in the post-Newtonian approximation of the Brans–Dicke theory, and applied to the problem of the dynamical instability of gaseous masses. It is found that the Brans–Dicke theory modifies the results of the theory of general relativity only by changing the numerical coefficients of the terms already present in the latter theory. And the dynamical instability predicted by general relativity is slightly suppressed in the Brans–Dicke theory. (auth)

**20655** COMA CLUSTER AS A SPHERICAL INHOMOGENEITY IN RELATIVISTIC DUST. Kantowski, Ronald (Southwest Center for Advanced Studies, Dallas). Astrophys. J., 155: 1023-7(Mar. 1969).

A dynamical model for spherical inhomogeneities in the mean mass density of the Universe is used to predict the velocity dispersion observed for the Coma Cluster. (auth)

**20656** THE LOG N–LOG S RELATION AND LUMINOSITY FUNCTIONS FOR RADIO SOURCES IN FRIEDMANN UNIVERSES. Petrosian, Vahe (California Inst. of Tech., Pasadena). Astrophys. J., 155: 1029-45(Mar. 1969).

The log N–log S diagram of the radio sources in the revised 3C catalog is discussed in two representative Friedmann universes: a conventional model of zero cosmological constant and a Lemaître-type model. The redshifts of about one hundred 3C sources indicate a uniform distribution of these radio sources in the Lemaître model enabling one to obtain a radio-luminosity function at 178 Mc. Using this luminosity function it is shown that the log N–log S diagram of the 3C sources can be explained in the Lemaître models without evolutionary effects. It is also shown that in these models uniformly distributed discrete radio sources are sufficient to produce the observed background temperature at 178 Mc. Other radio-source surveys are briefly discussed. The log N–log S diagram of the 4C and 5C sources can be explained in Lemaître models with a luminosity function which allows a density evolution of the form $(1+z)^3$, expected from the interaction of an expanding radio source with the intergalactic matter. (auth)

**20657** SCREENING OF DISTANT OBJECTS IN UNIVERSES WITH POSITIVE COSMOLOGICAL CONSTANT. Roeder, R. C.; Verreault, R. T. (Univ. of Toronto, Richmond Hill, Ont.). Astrophys. J., 155: 1047-59(Mar. 1969).

The probability of radiation from a distant emitter passing through an intervening galaxy was evaluated for model universes with positive cosmological constant and positive, zero, or negative spatial curvature. It is found that in those models with positive curvature the probabilities are significantly higher than in other cases. The probability function of one model is used to calculate the number of quasi-stellar objects which might show the effect, and an attempt at comparison with observations is made. It appears that at present it is not possible to assert definitely whether or not the effect is being observed. Finally, it is noted that the presence or absence of this effect can serve as an important test of certain model universes. (auth)

**20658** NUMEROLOGY AND LOCAL QUASI-STELLAR OBJECTS. Smernoff, Barry J. (Brandeis Univ., Waltham, Mass. Lincoln Lab., Lexington, Mass.). Astrophys. J., 155: L139-40 (Mar. 1969).

The assumption of energy release in QSO's through nonmassive gravitational-collapse episodes is shown to be consistent with local objects. (auth)

## Planetary Phenomena

**20659** PLANETES ET SATELLITES. MONDES DE L'ESPACE. (Planets and Satellites. World of Space). Guerin, Pierre. Paris, Larousse, 1967. 308p.

Topics covered include the solar system's place in the Universe, instruments and methods of observation, structure of the planets

and origin of the solar system, surfaces of the planets, radio-astronomy and planetary environments, and other planetary systems in the Universe. The book is extensively illustrated. (W.D.M.)

**20660** ROCKET MEASUREMENT OF ULTRAVIOLET SPECTRA OF VENUS AND JUPITER BETWEEN 1200 AND 1800 A. Moos, H. Warren; Fastie, William G.; Bottema, M. (Johns Hopkins Univ., Baltimore). Astrophys. J., 155: 887-97(Mar. 1969).

Low-resolution spectra of the planets Venus and Jupiter between 1200 and 1800 Å were obtained using a servo-controlled, star-tracking telescope in a very accurately pointed Aerobee rocket. The Venusian Lyman-$\alpha$ signal corresponded to a brightness of 18 kR. There is a feature at 1300 Å which is interpreted as evidence for the existence of oxygen in the upper atmosphere of Venus. Jupiter gives a relatively strong Lyman-$\alpha$ signal, about one-eighth of the maximum possible from scattering of solar Lyman-$\alpha$. Jupiter has a high albedo of ~0.2 at the longer wavelengths. The upper part of the Jovian atmosphere contains no observable $NH_3$. (auth)

## Atomic and Molecular Physics

*Refer also to abstracts 20593, 20990, 20991, 21031, 21230, 21278, 21331, 21383, and 21410.*

**20661** (ANL-Trans-724) RANGE AND IONIZATION LOSSES OF PROTON ENERGY IN DIFFERENT MATERIALS. Vasilevskii, I. M.; Karpov, I. I.; Petrukhin, V. I.; Prokoshkin, Yu. D. (Joint Inst. for Nuclear Research, Dubna (USSR)). Translated for Argonne National Lab., Ill., from report JINR-P1-4081. 24p. Dep. CFSTI.

An abstract of the original Russian report appears as NSA 23: 3251. (L.M.T.)

**20662** (NP-17810) STEPWISE IONIZATION AND ATOMIC LEVEL POPULATIONS IN A HELIUM DISCHARGE. Rijnhuizen Report 69-50. Mewe, R. (Stichting voor Fundamenteel Onderzoek der Materie, Jutphaas (Netherlands). Instituut voor Plasma-Fysica). Feb. 1969. 91p. Dep.

A study was made of the ionization of excited atoms in a gas discharge in helium. On the basis of a simplified helium level diagram the density of the atoms in the excited states $2^1S$, $2^1P$, $2^3S$, and $2^3P$ and the rate of ionization have been computed for a stationary homogeneous plasma cylinder. The calculations have been done on a computer in the following range of parameters: filling gas pressure p = 0.1 – 10 Torr, electron density $n_e = 10^{14} - 10^{18}$ $m^{-3}$, reduced axial electric field E/p = 100 to 6000 V $m^{-1}$ $torr^{-1}$, and plasma radius R = 0.005 to 0.02 m. The following processes are taken into account: excitation and ionization by electron impact of excited or ground state helium atoms, de-excitation of helium atoms by collisions with electrons (e.g., also coupling between singlet and triplet system) or with atoms (e.g., Penning ionization), radiative de-excitation (associated with radiation trapping in the case of a resonance line), and diffusion of excited atoms to the wall. As for the electron energy distribution, which deviates from a Maxwellian distribution, use is made of recent calculations in which the Boltzmann equation is solved numerically. The ionization theory has been applied to the case of an axially homogeneous positive column without magnetic field. Under the conditions mentioned above the column can be treated as a plasma in which the production of charge carriers by volume ionization in the gas is balanced by the loss due to the ambipolar diffusion to the wall. Deviations from the ambipolar diffusion theory, occurring when the electron and ion mean free paths and the electron Debye length become comparable with the plasma radius, are briefly considered. The theory agrees well with measurements of the electric field along the positive column of a glow discharge in helium with parameters: p = 0.1 to 2 torr, $n_e = 1.5 \times 10^{15}$ to $5 \times 10^{17}$ $m^{-3}$, tube current I = 0.01 to 0.4 A, E/p = 300 to 4000 V $m^{-1}$ $torr^{-1}$, R = 0.011 m, and tube length L = 1.4 m. A dual-beam absorption experiment has been carried out on the same discharge to check the calculated level populations. The radiation from an electrodeless rf helium source is passed across the positive column. The measured attenuation at the wavelength of a particular spectral line yields the population density of the lower level of this line. In the case of the triplet lines the influence of the fine structure on the absorption has been calculated. In the region where no striations occur in the positive column the measured and the calculated level populations agree within a factor of two. (auth)

**20663** (ORO-2408-9) THE BORN APPROXIMATION IN COLLISIONS OF HEAVY CHARGED PARTICLES WITH INNER SHELL ELECTRONS. Basbas, George James (North Carolina Univ., Chapel Hill). 1968. 41p. Dep. CFSTI.

Thesis.

Numerical calculations in the Born approximation are made for K-shell ionization by heavy-charged-particle impact. The purpose of the calculations is to assess the importance of nuclear Coulomb repulsion and the description of the atomic screening in estimating ionization cross sections. Comparisons of the T-matrix and excitation function are made with the Bethe plane-wave Born approximation results in the context of simplifying approximations employed to facilitate computations. A Coulomb wave function description for the heavy charged particle gives a significantly lower result than the corresponding Bethe plane-wave Born approximation result. A Hartree–Fock–Slater description of the atomic electrons causes a slight increase over results based on the screened hydrogenic atomic description used in the Bethe plane-wave Born approximation. Sample calculations are for 60- to 1600-keV protons on copper. (auth)

**20664** (UCRL-17859) CHARACTERIZATION OF MULTICHANNEL SOURCES AND DESIGN OF MOLECULAR BEAM SYSTEMS FOR THEIR UTILIZATION. Jones, R. H.; Kruger, V. R.; Olander, D. R. (California Univ., Berkeley. Lawrence Radiation Lab.). Dec. 1968. Contract W-7405-eng-48. 72p. Dep. CFSTI.

An apparatus for measuring the leak rates and angular distributions of the molecular flux from multichannel sources was constructed. Four types of beam sources were tested: a single capillary, a krinkly-foil stack, an electron-beam-milled quartz membrane, and two sources constructed by fiber optics techniques (Mosaic sources). The leak rates of the sources were compared to the predictions of Knudsen flow. The conductances of the Mosaic sources were 30 to 60% smaller than expected, possibly because of blockage of some of the channels. The conductances of the quartz-membrane and krinkly-foil sources were considerably greater than the values predicted by Knudsen flow indicating the presence of leakage paths other than the observed channels. The conductance of the single-capillary source was close to theory. The angular distributions were characterized by a peaking factor, defined as the ratio of the center-line beam intensity from the source to that from a cosine emitter of the same total flow rate. A semi-empirical formula was developed to correlate the peaking factors with the source pressure and Clausing factor of the channels. The correlation contained three terms: a molecular flow contribution derived by modification of the long tube Giordmaine–Wang calculation for short tubes; an empirical slip flow term; and a viscous flow term chosen to approach the peaking factor predicted from isentropic flow theory at high source pressures. All measured peaking factors, except for that from the krinkly-foil source, adequately fit the correlation. (auth)

**20665** ELECTRON EMISSION FROM MOLYBDENUM AND PLATINUM DURING BOMBARDMENT BY NEGATIVE CHLORINE IONS. Khashimov, N. M.; Nadyrshina, A. F. (Physical-Technical Inst., Dushanbe, USSR). Dokl. Akad. Nauk Tadzh. SSR, 11: No. 5, 19-21(1968). (In Russian).

Coefficients of ion–electron emission from untreated and pure platinum and molybdenum targets were measured using the inertia-free double modulation method in a vacuum exceeding $10^{-6}$ torr. The platinum was annealed at ~1900°K and the molybdenum was annealed at ~2800°K. The measurements were made at 1200°K. The results of measurements showed that the $\gamma^-$ dependence on the energy of bombarding $^{37}Cl^-$ and $^{35}Cl^-$ ions coincided. It was also shown that the electron emission during metallic target bombardment by positive and negative potassium ions, neutral argon atoms, and negative chlorine ions (having identical electron structure and almost identical masses) was similar, confirming the lack of dependence of ion–electron emission coefficients on the charge of the bombarding particles. (R.V.J.)

**20666** INVESTIGATION OF THE SPECTRUM OF ELECTRONS RELEASED UPON COLLISION OF $Ar^+$ IONS WITH Ar ATOMS. Ogurtsov, G. N.; Flaks, I. P.; Avakyan, S. V.; Fedorenko, N. V. (Ioffe Inst. of Physics and Tech., Leningrad). JETP Lett. (USSR) (Engl. Transl.)., 8: 330-2(Nov. 20, 1968).

Translated from Zh. Eksp. Teoret. Fiz., Pis'ma Redaktsiyu, 8: 541-4(Nov. 20, 1968).

The energy spectrum of electrons released in collisions of $Ar^+$ ions with Ar atoms was measured at three values of the collision energy (5, 15, and 25 keV) and in the electron-energy range 5 to 300 eV. The spectrum shows a continuous part that decreases smoothly with increasing electron energy in accordance with a power law and a structure superimposed on it. In the structure part, several line groups are distinguished and attributed to excitation of L and M shells and autoionization transitions. It is concluded that, when the colliding particles come close together, a strong overlap of the shells takes place in the quasimolecule produced, leading to excitation of the system and formation of vacancies in the inner shells. Lifting of this excitation by means of autoionization transitions can take place both after the separation of the atomic particles and at the instant of collision. (A.G.W.)

**20667** PHOTOELECTRIC CROSS-SECTIONS OF GAMMA-RAYS IN Ta, Pt, AND Pb AT 84 AND 100 keV. Rao, P. V. Ramana; Visweswara Rao, V.; Rama Rao, J.; Parthasaradhi, K. (Andhra Univ., Waltair, India). Nuovo Cim., Lett., 1: 311-12 (Feb. 21, 1969).

Photoelectric cross sections in Ta, Pt, and Pb were determined by measuring total gamma-ray cross sections and subtracting theoretical scattering cross sections. The gamma sources $^{153}Gd$ and $^{170}Tm$ were used to provide energies of 84 and 100 keV, respectively. Results are compared with recent theoretical and compiled data. Agreement is considered to be satisfactory. (A.G.W.)

**20668** NUMERICAL CALCULATION OF K-SHELL PHOTO-EFFECT. Hultberg, S.; Nagel, B.; Olsson, P. (Royal Inst. of Tech., Stockholm). Ark. Fys., 38: 1-96(1968).

Numerical calculations were carried out of the relativistic K-shell photoeffect for elements with Z from 1 to 100 and incident photon energies from 1 keV to 10 MeV, the upper limit being arbitrarily set. The calculations comprise integrated cross sections $\tau$, differential cross sections $\sigma(\theta)$ and seven polarization correlations $C_{ij}$, for a total of 254 cases. For $\tau$ and $\sigma(\theta)$ the results are presented in appended tables. A pure Coulomb potential was used, thus neglecting effects of screening. The method of analysis used is based on an expansion of the partial-wave matrix element in hypergeometric functions of two variables and their asymptotic forms for large multipole orders, permitting an arbitrary number of terms to be taken into account in the partial waves expansion. (Sweden)

**20669** RELATIVISTIC THEORY OF $H_2^+$. Luke, S. K. (York Univ., Toronto); Hunter, G.; McEachran, R. P.; Cohen, M. J. Chem. Phys., 50: 1644-50(Feb. 15, 1969).

The Dirac equation for $H_2^+$ is reduced to a form similar to that of the Schrödinger equation with some perturbation terms. A first-order perturbation calculation for the $1s\sigma_g$ state then reveals that these relativistic effects lower the electronic energy by a small amount of order $0.2\alpha^2$ for most internuclear separations and thereby make the molecule slightly more stable. The formalism is readily generalized to the isoelectronic sequence of $H_2^+$, and the ratio of the relativistic correction to the nonrelativistic energy is found to be of order $Z^2\alpha^2$. Consequently, the relativistic correction becomes progressively more important as Z increases. (auth)

**20670** ASYMPTOTIC CORIOLIS INTERACTIONS IN SLOW ATOMIC COLLISIONS. Thorson, Walter R. (Univ. of Alberta, Edmonton). J. Chem. Phys., 50: 1702-4(Feb. 15, 1969).

In slow atomic collisions there appear formal long-range interactions between axis-coupled (BO) states due to asymptotic Coriolis interactions, which behave as $R^{-2}$. It is shown that these long-range interactions are usually of trivial significance and can be ignored. An error in the asymptotic correlation proposed earlier by us is corrected. (auth)

**20671** QUANTUM-MECHANICAL FORMULAS FOR THE INELASTIC SCATTERING OF FAST ELECTRONS AND THEIR COMPTON LINE SHAPE. NONRELATIVISTIC APPROXIMATION. Tavard, C.; Bonham, R. A. (Indiana Univ., Bloomington). J. Chem. Phys., 50: 1736-47(Feb. 15, 1969).

A critical discussion is presented on the various ways to calculate the total inelastic electron scattering in the Born approximation. It is shown that the Morse approximation, the simplest and most frequently used, fails at small and large scattering angles. An improvement can be obtained by use of the "quasi-free-scattering" approximation first proposed by Bethe. An attempt is made to take into account the binding of the target electrons through their momentum distributions and in this way to correct Bethe's approximation for Doppler effects. This quantum-mechanical treatment shows the contribution of exchange terms to the Compton profile of the scattered electrons. (auth)

**20672** VIBRATION–ROTATION INTERACTION EFFECTS IN CALCULATED FRANCK–CONDON FACTORS. II. HYDROGEN LYMAN AND FULCHER BANDS. Villarejo, Don; Stockbauer, Roger; Inghram, Mark G. (Univ. of Chicago). J. Chem. Phys., 50: 1754-62(Feb. 15, 1969).

Calculated Franck–Condon factors, explicitly including previously neglected vibration–rotation interaction effects, are reported for 450 Lyman and 24 Fulcher bands of the hydrogen molecule. Large cancellation effects, depending on rotational quantum number, are found for a number of Lyman bands. Where comparison is possible, the results show good qualitative agreement with experimentally determined intensity distributions. Alternative representations of the $B\,^1\Sigma_u^+$ potential curve (upper state of the Lyman bands) are used to show that the calculated intensity distribution for some bands are highly sensitive to detailed features of the molecular potential curves. (auth)

**20673** ELASTIC SCATTERING, DIFFUSION, AND EXCITATION TRANSFER OF METASTABLE HELIUM IN HELIUM. Kolker, H. J.; Michels, H. H. (United Aircraft Corp., East Hartford). J. Chem. Phys., 50: 1762-71(Feb. 15, 1969).

The dynamics of the resonance collision of metastable and normal helium atoms has been examined and calculations have been performed for elastic scattering, diffusion, and excitation transfer. To facilitate this analysis, accurate ab initio calculations of the pertinent interaction potentials have been carried out. The use of these more accurate potential curves in the framework of the original dynamical formulation of the collision process by Buckingham and Dalgarno leads to serious discrepancies between calculations and experiment for the elastic-scattering cross section and the coefficient of diffusion. The rate constant for the excitation-transfer reaction, however, is in reasonable agreement with experiment over a wide range of temperatures. (auth)

**20674** ROLE OF WORK FUNCTION IN ELECTRON EJECTION BY METASTABLE ATOMS: HELIUM AND ARGON ON (111) AND (110) TUNGSTEN. MacLennan, D. A.; Delchar, T. A. (General Electric Research and Development Center, Schenectady, N. Y.). J. Chem. Phys., 50: 1772-8(Feb. 15, 1969).

A tungsten single crystal, cut to expose the (111) and (110) planes, was employed to examine the influence of the work function on electron ejection by beams of helium or argon metastable atoms. The (111) and (110) planes have work functions that differ by approximately 1.5 eV. The electron yield of the (111) surface, with incident helium metastable atoms, is about 1.5% higher than that of the (110) surface; with argon this difference is about 4%. The ejected-electron energy distributions are essentially the same for both crystal planes, but different distributions are obtained with helium and argon. The work-function values inferred from these measurements are the same for both crystal planes, but different values are obtained depending on which metastable-atom probe is used. These results differ from what has been previously predicted, and they are qualitatively accounted for by recognizing that the resonance ionized metastable atom strongly perturbs the surface electron cloud, causing the local vacuum potential to be shifted. The shift in vacuum potential is calculated for a one-dimensional model using a pseudopotential approximation for the resonance ionized metastable atom. (auth)

**20675** ADSORBATE EFFECTS IN ELECTRON EJECTION BY RARE-GAS METASTABLE ATOMS. Delchar, T. A.; MacLennan, D. A.; Landers, A. M. (General Electric Research and Development Center, Schenectady, N. Y.). J. Chem. Phys., 50: 1779-87(Feb. 15, 1969).

The effect of adsorbed-gas layers on the ejection of electrons by rare-gas metastable atoms was investigated for some tungsten surfaces. These surfaces were the (111) and (110) planes of a tungsten single crystal and an essentially (100) oriented polycrystalline tungsten ribbon. With nitrogen as the adsorbate the ejected-electron yields were reduced by 42% on the polycrystalline ribbon and increased 1% on the (111) plane. The yield did not change for the (110) plane. With carbon monoxide as the adsorbate, the yield decreases were 63%, 51%, and 56% for the polycrystalline ribbon, the (100), and (111) planes, respectively. With hydrogen as the adsorbate the yield was decreased by 1% on the (110) plane and 4% on the (111) plane. In those cases where the ejected-electron yield was sharply reduced following adsorption, the electron energy spectrum revealed a marked diminution of the number of high-energy electrons and in the case of carbon monoxide on the (111) and (110) planes, essentially a "cutoff" in the energy spectrum. No correlation was found between the yield changes and the known work-function changes accompanying adsorption. The effectiveness of each adsorbate in reducing the ejected-electron yield was in the order $CO > N_2 > H_2$. For CO it was found that the decrease in yield of ejected electrons was proportional to the number of CO atoms that had impinged on the surface. By this means the sticking coefficient for CO on the (111) and (110) planes was estimated to be unity. The results are interpreted with a model in which bonding electrons from the adsorbed atom participate in the ejection process, the degree of participation depending on the surface density of the adsorbed atoms as well as their size and position on the surface. The theory, applied to the data for CO, predicts that the CO bonding electrons lie 12.6 eV below the vacuum level. It is inferred also that nitrogen atoms adsorbed on the (111) plane lie in the surface, while on the (100) plane they protrude from the surface. (auth)

**20676** PRODUCTION OF EXCITED HYDROGEN ATOMS BY IMPACT OF FAST ELECTRONS ON WATER VAPOR. Vroom, D. A.; de Heer, F. J. (FOM-Instituut voor Atoom- en Molecuulfysica Amsterdam). J. Chem. Phys., 50: 1883-7(Feb. 15, 1969).

Lyman-$\alpha$ and Balmer-$\alpha$, -$\beta$, -$\gamma$, and -$\delta$ radiation has been observed resulting from dissociative excitation of water vapor by fast electrons. Absolute cross sections for emission of this radiation are reported in the electron energy range from 50 to 6000 eV. The results are analyzed by means of the Bethe approximation. Of all the relevant dissociative states of the molecule formed during the collision process, those populated by optically allowed transitions predominate. The relatively large cross sections for dissociative excitation producing excited hydrogen atoms may indicate the importance of such species in the radiolysis of water. (auth)

**20677** SYMMETRY OF THE TWO-DIMENSIONAL HYDROGEN ATOM. Cisneros, Arturo; McIntosh, Harold V. (Instituto Politecnico Nacional Mexico, Mexico City). J. Math. Phys. (N. Y.), 10: 277-86(Feb. 1969).

A paradox has arisen from some recent treatments of accidental degeneracy that claim that, for three degrees of freedom, SU(3) should be a universal symmetry group. Such conclusions are in disagreement both with experimentally observed spectra and with the generally accepted solutions of Schrödinger's equation. The discrepancy occurs in the transition between classical and quantum-mechanical formulations of the problems, and illustrates the care necessary in forming quantum-mechanical operators from classical expressions. The hydrogen atom in parabolic coordinates in two dimensions, for which the traditional treatment of Fock, extended by Alliluev, requires the symmetry group O(3), is a case for which the newer methods of Fradkin, Mukunda, Dulock, and others require SU(2). Although these groups are only slightly different, SU(2) fails to be the "universal" symmetry group on account of the multiple valuedness of the parabolic representation. This conclusion extends a result of Han and Stehle: that, for rather similar reasons, SU(2) cannot be the classical symmetry group for the two-dimensional hydrogen atom. (auth)

**20678** ION POLARIZATION VIA PENNING COLLISIONS WITH OPTICALLY PUMPED METASTABLE HELIUM. Schearer, L. D. (Texas Instruments Inc., Dallas). Phys. Rev. Lett., 22: 629-31(Mar. 31, 1969).

Transfer of spin polarization from optically pumped metastable helium atoms to the ions of Cd, Sr, and Zn following Penning collisions has been demonstrated; this indicates that a component of spin angular momentum is conserved. The ion polarization, detected optically, exceeds 10% at ion concentrations on the order of $10^{10}$ to $10^{11}$ $cm^{-3}$. (auth)

**20679** ISOTOPE SHIFTS IN THE 4416-A CADMIUM LASER. Hopkins, B. D.; Fowles, G. R. (Univ. of Utah, Salt Lake City). IEEE (Inst. Elec. Electron. Eng.), J. Quant. Electron., QE-4: 1013-15(Dec. 1968).

Isotope shifts in $^{112}Cd$, $^{114}Cd$, and $^{116}Cd$ have been measured using enriched isotopes in a cadmium laser. Preparatory measurements using natural cadmium showed an anomalous change from a double-peaked spectral profile to a single-peaked profile when the active tube length was doubled. (auth)

**20680** EFFECT OF CYCLIC DEFORMATION ON POSITRON LIFETIMES IN COPPER AND ALUMINUM. Grosskreutz, J. C. (Midwest Research Inst., Kansas City, Mo.); Millett, W. E. Phys. Lett., 28A: 621-2(Feb. 10, 1969).

Positron lifetimes in annealed and cyclically deformed aluminum and copper were measured by the delayed-coincidence method. The deformation increased the lifetime of the primary component by 26% in Al and by 46% in Cu. It is proposed that trapping of positrons in dislocation cores can account for the observations. (auth)

**20681** IMPROVED BOND-STRETCHING-ENERGY CURVES FROM THE INTEGRAL HELLMANN-FEYNMAN METHOD. Mazziotti, Alexander; Lowe, John P. (Pennsylvania State Univ., University Park). J. Chem. Phys., 50: 1153-9(Feb. 1, 1969).

The connection between the local-energy concept and the integral Hellmann-Feynman (IHF) method is used to obtain an improved bond-stretching-energy curve from short one-center expansions of $HeH^+$. An alternative method of analyzing the IHF method, based on spectral impurities, is developed. It is shown how this formalism also enables one to rationalize and predict IHF results. IHF calculations on single-center expansions for $H_2$ are reported. It is concluded that, for single-center expansions (especially when centered at a nucleus), the IHF method is a very promising way to get improved bond-stretching energies. (auth)

**20682** MOLECULAR COLLISIONS. IX. RESTRICTED DISTORTED-WAVE APPROXIMATION FOR ROTATIONAL EXCITATION AND SCATTERING OF DIATOMIC MOLECULES. Curtiss, C. F.; Bernstein, R. B. (Univ. of Wisconsin, Madison). J. Chem. Phys., 50: 1168-76(Feb. 1, 1969).

The general expression for rotational excitation and scattering cross sections for rigid diatomic molecules derived in Paper VIII is reduced to yield a restricted distorted-wave approximation, resulting in a relatively simple equation for the inelastic transition probabilities. The new expressions possess significant advantages over analogous ones of Davison and of Arthurs and Dalgarno because of the elimination of certain multiple summations. The results are, however, demonstrated to be identical by direct resummation methods. For a potential that is separable into a product of a radial and an angular function, the dependence of the transition probability upon the anisotropy parameters is given explicitly. (auth)

**20683** PROJECTED HARTREE PRODUCT WAVEFUNCTIONS. III. COMPARISON WITH THE CI METHOD FOR $H_2$. Morrison, R. C.; Gallup, G. A. (Univ. of Nebraska, Lincoln). J. Chem. Phys., 50: 1214-18(Feb. 1, 1969).

Calculations of the energy of $H_2$ have been performed using both the projected Hartree-Fock (PHF) method and a full configuration interaction (CI) method in the same basis for comparison of the two methods. It is discovered that PHF can account for 86% of the correlation energy, whereas CI will account for 88% of the correlation energy. (auth)

**20684** PROJECTED HARTREE PRODUCT WAVEFUNCTIONS. II. GENERAL CONSIDERATIONS OF YOUNG OPERATORS. Gallup, G. A. (Univ. of Florida, Gainesville). J. Chem. Phys., 50: 1206-14(Feb. 1, 1969).

A discussion is given of the forms of two specific and one general Young operator for the irreducible representations of $S_n$ important for fermion space functions. Comparisons are made of the projected Hartree-product version of Löwdon's projected Hartree-Fock method with configuration-interaction calculations. (auth)

**20685** SIMULTANEOUS PHOTOEXCITATION AND PHOTOIONIZATION OF HELIUM. Samson, James A. R. (Geophysics Corp. of America, Bedford, Mass.). Phys. Rev. Lett., 22: 693-4(Apr. 7, 1969).

The probability of simultaneously photoexciting and photoionizing helium has been measured near threshold at a wavelength of 186 Å. It was found that about $(8 \pm 2)\%$ of the ions formed at that wavelength were excited into the n = 2 state. (auth)

**20686** GENERALIZED OSCILLATOR STRENGTH FOR $1^1S \rightarrow 2^1P$ TRANSITION OF HELIUM. THEORY OF LIMITING OSCILLATOR STRENGTHS. Lassettre, Edwin N.; Skerbele, Ausma; Dillon, Michael A. (Carnegie-Mellon Univ., Pittsburgh). J. Chem. Phys., 50: 1829-39(Feb. 15, 1969).

Relative generalized oscillator strengths have been determined for the $1^1S \rightarrow 2^1P$ transition in helium as a function of momentum change of the colliding electron and normalized to the theoretical oscillator strength calculated by Schiff and Pekeris [Phys. Rev., 134: A638 (1964)] at zero momentum change. The validity of the normalizing procedure is investigated theoretically and it is shown that the limit of the generalized oscillator strength at zero momentum change is equal to the optical oscillator strength for any atom or molecule at any incident energy regardless of whether the first Born approximation holds. The normalizing procedure is therefore justified. The results are compared with the experimental and theoretical oscillator strengths obtained by other investigators. The limiting relation for oscillator strengths is established under much more general conditions than in any previous research. (auth)

**20687** THEORETICAL JUSTIFICATION OF THE APPARENTLY ANOMALOUS LOW-ENERGY BEHAVIOR OF SOME ION-MOLECULE REACTIONS. Kaufman, Joyce J. (Martin Marietta Corp., Baltimore); Koski, Walter S. J. Chem. Phys., 50: 1942-5(Mar. 1, 1969).

It is generally observed that cross sections for exothermic ion-molecule reactions decrease with increasing ion kinetic energies indicating a negligible activation energy. An important exception to this behavior is exhibited by the exothermic reaction $O^+ + N^2 \rightarrow NO^+ + N$, the cross section of which goes through a maximum as a function of ion energies. A study of the pertinent potential-energy curves, taking into account the proper symmetry- and spin-allowed combinations of the reactants and products, shows the origin of the apparently anomalous behavior of this reaction. (auth)

**20688** PAIR POLARIZABILITY OF HYDROGEN ATOMS. RELATION TO COLLISION-INDUCED LIGHT SCATTERING AND DIELECTRIC PHENOMENA IN RARE GASES. DuPre, Donald B.; McTague, J. P. (North American Rockwell Corp., Thousand Oaks, Calif.). J. Chem. Phys., 50: 2024-8(Mar. 1, 1969).

The polarizability tensor as a function of internuclear separation of hydrogen atoms is calculated, using the approximate variational wave function for ground- and first-excited-state $H_2$ of Hirschfelder and Linnett. Two interacting hydrogen atoms in the non-

bonding triplet state have certain qualitative features in common with colliding pairs of rare-gas atoms. In particular, the system exhibits the long-range dispersion attraction and short-range overlap repulsion of interacting closed-shell atoms. Results of the calculations here on $^3\Sigma H_2$ are capable, in analogy, of explaining observed trends in collision-induced light scattering intensities and the second dielectric virial coefficient of rare gases, which cannot be accounted for on the basis of long-range dispersion force models or perturbation theory along. The major source of the effect is found to be the distortion of electronic charge density at intermediate and small internuclear separations. (auth)

**20689** COLLISIONS OF MONOENERGETIC ELECTRONS WITH $NO_2$: POSSIBLE LOWER LIMITS TO ELECTRON AFFINITIES OF $O_2$ AND NO. Stockdale, J. A. D.; Compton, R. N.; Hurst, G. S.; Reinhardt, P. W. (Oak Ridge National Lab., Tenn). J. Chem. Phys., 50: 2176-80(Mar. 1, 1969).

The yields of $O^-$, $NO^-$, and $O_2^-$ ions produced by dissociative attachment of electrons to $NO_2$ have been studied as a function of the electron energy from 0 to 6 eV. A modulated retarding-potential-difference technique permitted electron-energy resolution of approximately 0.1 eV. The measured appearance potentials for $NO^-$ and $O_2^-$ were found to be consistent with an electron affinity of $\geq 0.65$ eV for NO and $\geq 1.1$ eV for $O_2$. These lower limit measurements to the electron affinities of $O_2$ and NO are discussed in relation to previous studies of electron attachment to these molecules. (auth)

**20690** DE-EXCITATION CROSS SECTION OF $(NO^+)^*$ IN NO. Mathis, R. F.; Turner, B. R.; Rutherford, J. A. (Gulf General Atomic Inc., San Diego, Calif.). J. Chem. Phys., 50: 2270-1(Mar. 1, 1969).

The cross section for the de-excitation of excited $NO^+$ during collisions with neutral NO at nearly thermal energy was computed from measurements of the fraction of excited ions in a beam as a function of number density in the source. The cross section was found to be $3.3 \pm 2 \times 10^{-15}$ cm$^2$. Experiments carried out under various source conditions indicated that the cross section is not strongly energy-dependent in this region. (A.G.W.)

**20691** $\pi^-$-MESON CAPTURE IN A HYDROGEN–DEUTERIUM GAS MIXTURE. Petrukhin, V. I.; Prokoshkin, Yu. D. (Joint Inst. for Nuclear Research, Dubna, USSR). Zh. Eksp. Teor. Fiz., 56: 501-4(Feb. 1969). (In Russian).

Capture of $\pi^-$ mesons from hydrogen by deuterium in a $H_2 + D_2$ gas mixture is investigated. The capture features can be explained within the framework of the phenomenological model. (auth)

**20692** DIFFERENTIAL ELASTIC SCATTERING CROSS SECTIONS OF 145-keV GAMMA RAYS FROM DIFFERENT ELEMENTS AT SMALL ANGLES. Ghumman, B. S.; Sood, B. S. (Punjabi Univ., Patiala, India). Indian J. Pure Appl. Phys., 7: 7-9(Jan. 1969).

The differential elastic scattering cross sections of 145-keV gamma rays from lead, tin, silver, copper, iron, and aluminum were measured at nine angles in the range 3 to 16°. The results when compared with the available theoretical data were found to show better agreement with the form factor calculations of A. T. Nelms and I. Oppenheim for the Hartree model than with those for the Fermi–Thomas model. (auth)

**20693** ELECTRON CAPTURE BY PROTONS FROM HYDROGEN MOLECULES. Sural, D. P.; Sil, N. C. (Indian Association for the Cultivation of Science, Calcutta). Indian J. Phys., 42: 323-5(May 1968).

The coupled differential equations for calculating the cross section for the process $\bar{p} + H_2 \rightarrow H + H_2^+$ obtained by using the impact-parameter formulation with a two-state approximation (in atomic units) are $F_{11}A + 2^{\frac{1}{2}}(F_{11} - \frac{1}{2} if'_{11})B - iA - 2^{\frac{1}{2}} if_{11}B = 0$, and $2^{\frac{1}{2}}(F_{11} - \frac{1}{2} if'_{11})A + (F_{11} + F_{12} - \frac{1}{2} if'_{12})B - 2^{\frac{1}{2}} if_{11}A - i(1 + f_{12})B = 0$. Solutions for these equations are derived. (M.O.W.)

**20694** TOTAL CROSS SECTIONS OF 280-keV GAMMA RAYS IN Pb, Pt, AND Sn. Parthasaradhi, K.; Rama Rao, J.; Rao, P. V. Ramana (Andhra Univ., Waltair, India). J. Phys., A (London), 2: 245-6(Mar. 1969).

Experimental total cross sections of 280-keV gamma rays were determined because of the inadequacy of the available data for Pb, Pt, and Sn. Satisfactory agreement was observed between experimental values and theoretical values computed with the latest data on photoelectric coherent and incoherent scattering cross sections. (auth) (UK)

**20695** VELOCITY SELECTOR FOR MOLECULAR BEAMS. Kodera, Kumasaburo; Kusunoki, Isao (Kyoto Univ.). Oyo Butsuri, 38: 20-4(Jan. 1969). (In Japanese).

A mechanical velocity selector for molecular beams has been constructed and tested. It is similar to that reported by Hostettler and Bernstein, except that slits are cut obliquely. Therefore, Miller and Kusch's treatment originally given for a cylinder-type velocity selector with spiral grooves can be applied to problems of velocity resolution and transmission. The selector has a high resolution (3.96%) and a very high transmission (47.6%). The transmitted velocity was 1500 m/sec at the highest rotor speed used (25,000 rpm). A potassium beam has been velocity analyzed and the results were found to be in good agreement with the calculated distribution. (auth) (NSA of Japan)

**20696** MANY-ELECTRON PSEUDOPOTENTIAL FORMALISM FOR ATOMIC AND MOLECULAR EXCITED-STATE CALCULATIONS. Tully, John C. (Univ. of Chicago). Phys. Rev., 181: 7-22(May 5, 1969).

The pseudopotential approach of Phillips and Kleinman is extended beyond the one-electron approximation for the purpose of obtaining correlated low-energy continuum and excited bound states of atomic and molecular systems with a minimum of computational effort. Pseudopotential equations are derived by a variational method. These and other nonvariational pseudopotential methods are shown to be quite useful in conjunction with either adiabatic or close-coupling methods. Calculations are performed on the following two-electron systems: e–H $^1$S-wave elastic scattering, e–He$^+$ $^1$S and $^3$S elastic scattering, and $^1$S and $^3$S Rydberg states of He. In general, good results are obtained. The calculated Rydberg-state quantum defects usually agree with the experimental values to three decimal places, and the calculated e–H $^1$S zero-energy scattering length of $5.90 \pm 0.08$, which is a strict upper bound to the true value, compares favorably with the value $5.965 \pm 0.003$ obtained by Schwartz in a very much more involved calculation. The possible extension of these methods to larger atomic systems and to molecules is discussed. A differential equation method for obtaining bound-state wave functions and energies based on asymptotic properties of Coulomb functions is outlined in the Appendix. (auth)

**20697** SINGLET–TRIPLET MIXING IN THE HELIUM SEQUENCE. Drake, G. W. F. (Smithsonian Institution Astrophysical Observatory, Cambridge, Mass.). Phys. Rev., 181: 23-4(May 5, 1969).

Accurate variational calculations are presented for the off-diagonal matrix elements of the Breit interaction between the $2^1$P and $2^3$P states of several members of the helium isoelectronic sequence. A comparison is made with recent Z-expansion calculations, which are accurate through terms of order $\alpha^2 Z^3$. The comparison shows that the Z-expansion method for off-diagonal mixing is potentially useful in the theory of many-electron atoms. The effect of singlet-triplet mixing on the $2^3$P excitation cross sections is briefly discussed. (auth)

**20698** PERTURBATION TREATMENT OF THE HARTREE–FOCK EQUATIONS FOR $2p^2$ $^1$D AND $^3$P WEAKLY QUANTIZED STATES OF HELIUM-LIKE IONS. Sharma, C. S.; Wilson, R. G. (London Univ.). Phys. Rev., 181: 39-42(May 5, 1969).

The first-order Hartree–Fock (HF) equations for the $2p^2$ $^1$D and $^3$P states of two-electron atomic systems are solved exactly. The solutions are used to evaluate the second-order HF energies exactly and the third-order HF energies with great accuracy. The zero- and first-order terms in the expectation values of $1/r$, $r$, and $r^2$ are calculated for the 2p orbital in each case. The results of this paper for the $2p^2$ $^1$D state of the helium atom are compared with those of experiment and another calculation. (auth)

**20699** EVIDENCE FOR Rb–RARE-GAS MOLECULES FROM THE RELAXATION OF POLARIZED Rb ATOMS IN A RARE GAS. THEORY. Bouchiat, C. C. (Faculte des Sciences, Orsay, France); Bouchiat, M. A.; Pottier, L. C. L. Phys. Rev., 181: 144-65(May 5, 1969).

Relaxation experiments performed on optically polarized Rb atoms in a rare gas have been previously reported; their detailed interpretation is given below. It is shown that the relaxation governed by the spin–orbit interaction is strongly affected by the formation of chemically unstable Rb–Kr molecules bound by van der Waals forces. Two processes of molecule formation are analyzed: binary resonant collisions leading to metastable states and three-body collisions producing actual bound states. A relaxation model valid for any disorientation probability per single Rb–Kr interaction is developed. Aside from clear evidence for the existence of alkali–rare-gas molecules, the success of the theoretical interpretation of the relaxation experiments yields the equilibrium constant $K = 1.7 \times 10^{-22}$ cm$^3$/molecule for the reaction Rb + Kr $\rightleftharpoons$ Rb–Kr at 300°K, the average lifetime of a Rb–Kr molecule in the gas phase, $\tau = 0.65 \times 10^{-7}$ sec, at a krypton pressure of one torr, and the average spin–orbit coupling constant in a Rb–Kr molecule, $\bar{\nu}h^{-1} = 0.63$ MHz. It is also shown that the spin–orbit potential is predominantly short-range. (auth)

**20700** TIME-DEPENDENT SEMICLASSICAL SCATTERING THEORY. I. POTENTIAL SCATTERING. Pechukas, Philip (Columbia Univ., New York). Phys. Rev., 181: 166-74(May 5, 1969).

The semiclassical theory of potential scattering is derived from Feynman's path-integral formulation of quantum mechanics. Since the partial-wave expansion is avoided, the results are applicable to scattering by a noncentral field. Special attention is given to the conditions for validity of the semiclassical approximation. (auth)

**20701** TIME-DEPENDENT SEMICLASSICAL SCATTERING THEORY. II. ATOMIC COLLISIONS. Pechukas, Philip (Columbia Univ., New York). Phys. Rev., 181: 174-85(May 5, 1969).

Classical equations are derived for the relative motion of two atoms as their insides make a given quantum transition. The classical changes in relative energy and angular momentum associated with this description just balance the corresponding quantum changes in internal energy and angular momentum for the transition involved. The work is based on a generalization of Hamilton's principle, suggested in a natural way by Feynman's formulation of quantum mechanics; the semiclassical scattering theory that emerges is, in essence, a justification and extension of the impact-parameter method. Applications to low-energy atomic collisions are discussed briefly. (auth)

**20702** COMPTON SCATTERING FROM A BOUND SYSTEM OF TWO CHARGED PARTICLES. Bisiacchi, Giordano (Univ. of Rochester, N. Y.); Calucci, Giorgio. Phys. Rev., 181: 185-91(May 5, 1969).

With reference to a previous paper by Fronsdal, the expression for Compton scattering on the fundamental state of the hydrogen atom is derived, taking into account the effect of the proton motion. An example of its extension to an inelastic case is shown. The result is discussed in connection with some problems of interpretation of the formalism of the infinite-component wave functions. (auth)

**20703** COUPLED-STATE CALCULATIONS OF PROTON–HELIUM SCATTERING. van den Bos, J. (Joint Inst. for Lab. Astrophysics, Boulder, Colo.). Phys. Rev., 181: 191-7(May 5, 1969).

The impact-parameter method was used to make calculations on the excitation of helium by protons in the kinetic-energy region of 10 to 10,000 keV. The total wave function of the system is expanded in a set of helium eigenstates including the n = 1, n = 2, and n = 3 (except for $3^1S$) states. The resulting linear differential equations (up to 18) have been solved numerically and compared with existing calculations and experiment. It is shown that for higher impact energies the many-state cross sections tend to the Born cross sections, but that for nonallowed transitions discrepancies exist up to very high energy. For allowed transitions, the agreement between theory and experiment is reasonable. Sublevel cross sections are shown to be very sensitive to the number of states retained in the expansion; only at the highest energies for which calculations have been done are they in agreement with Born sublevel cross sections. This fact is also shown by a comparison of calculated and measured polarization fractions of the emitted light induced by the excitations. (auth)

**20704** EXCITATION OF THE $3^{1,3}D$ AND $4^{1,3}F$ LEVELS OF HELIUM BY DIRECT ELECTRON IMPACT, AND $4^1P \rightarrow 4^{1,3}F$ COLLISIONAL TRANSFER. Anderson, R. J.; Hughes, R. H.; Norton, T. G. (Univ. of Arkansas, Fayetteville). Phys. Rev., 181: 198-205(May 5, 1969).

Excitation of the $3^{1,3}D$ and $4^{1,3}F$ levels of helium by electron impact has been studied by time-resolved spectroscopy of the $3^1D \rightarrow 2^1P(\lambda 6678\ \text{Å})$ and $3^3D \rightarrow 2^3P(\lambda 5876\ \text{Å})$ transitions. (Excitation of the $4^1F$ and $4^3F$ levels are observed as cascade components under time resolution.) Cross sections are estimated for the direct excitation of these levels by 38-, 50-, and 100-eV electron impact. Excitation of the 4F levels by direct electron impact is much larger than predicted by the Born approximation but much smaller than implied by previous experimental measurements. Direct excitation of the $3^1D$ and $4^1F$ by 100-eV electron impact is in excellent agreement and satisfactory agreement, respectively, with preliminary close-coupling approximation calculations. The collisional transfer $4^1P \rightarrow 4^3F$ is much smaller relative to the $4^1P \rightarrow 4^1F$ transfer than has previously been suggested. (auth)

**20705** GENERALIZED OSCILLATOR STRENGTHS OF THE HELIUM ATOM. II. TRANSITIONS FROM THE METASTABLE STATES. Kim, Yong-ki; Inokuti, Mitio (Argonne National Lab., Ill.). Phys. Rev., 181: 205-14(May 5, 1969).

The generalized oscillator strengths for the transitions $2^1S \rightarrow 2^1P$, $3^1S$, $3^1P$, $3^1D$, $4^1P$, and $2^3S \rightarrow 2^3P$, $3^3S$, $3^3P$, $3^3D$, $4^3P$ of He are computed from the Weiss correlated wave functions of the Hylleraas type. The results from two alternative formulas, corresponding to the "length" and "velocity" formulas in the optical limit, agree with each other within a few percent for moderate values of the momentum transfer. The first Born excitation cross sections for the above-mentioned transitions by charged-particle impact are also presented. (auth)

**20706** MEASURED ABSOLUTE CROSS SECTIONS FOR K* + Rb COLLISIONAL EXCITATION TRANSFER. Ornstein, Michael H.; Zare, Richard N. (Univ. of Colorado, Boulder). Phys. Rev., 181: 214-29(May 5, 1969).

The electronic excitation transfer processes, $K(^2P_{\frac{3}{2}}) + Rb(^2S_{\frac{1}{2}}) \rightarrow K(^2S_{\frac{1}{2}}) + Rb(^2P_{\frac{3}{2}}) + \Delta E$ and $K(^2P_{\frac{3}{2}}) + Rb(^2S_{\frac{1}{2}}) \rightarrow K(^2S_{\frac{1}{2}}) + Rb(^2P_{\frac{3}{2}}) + \Delta E$, have been studied by irradiating a cell containing a nonequilibrium mixture of potassium and rubidium vapors with either the 7665 Å D2 line or the 7699 Å D1 line of the potassium resonance doublet. The resulting collisionally induced rubidium 7948 Å fluorescence signal, isolated by interference filters used in tandem, is detected with a liquid-nitrogen–cooled S-1 photomultiplier placed at right angles to the direction of excitation. Measurements of the intensity ratio of the potassium and rubidium fluorescence combined with an optical absorption determination of the rubidium-atom density yields the following excitation transfer cross sections: $Q[K(^2P_{\frac{3}{2}}) \rightarrow Rb(^2P_{\frac{3}{2}})] = 2.2\ \text{Å}^2 \pm 25\%$ and $Q[K(^2P_{\frac{3}{2}}) \rightarrow Rb(^2P_{\frac{1}{2}})] = 2.6\ \text{Å}^2 \pm 20\%$ at $T = 365°K \pm 2\%$. Throughout an experimental run the potassium and rubidium vapor pressures are varied, but data are taken for only the lowest vapor pressures for which corrections due to resonance radiation imprisonment are unnecessary. (auth)

**20707** IMPACT IONIZATION IN THE PROTON–H-ATOM SYSTEM. I. THEORY. Thorson, Walter R. (Univ. of Alberta, Edmonton); Levy II, Hiram. Phys. Rev., 181: 230-44(May 5, 1969).

In a series of papers, of which this is the first, the calculation of the total cross section $\sigma_1(\epsilon)$ for the process $H^+ + H(1s) \rightarrow 2H^+(E') + e^-(\epsilon)$, for initial relative energies $E < 500$ eV, is described and performed. Here E' is the relative energy of the final protons. This paper (I) describes the theory used, and paper II describes the calculation and results for the electronic part of the problem (wave functions and transition matrix elements). Work is being completed on the trajectory integrals that form the last part of the calculation. $\sigma_1(\epsilon)$ is a total cross section with respect to scattering angles, but is differential in the final electron energy. The principle upon which the calculation is based is the approximate separability of electron and heavy-particle dynamics for both initial and final states, due to the mass disparity. The theory is an extension of that developed earlier by Thorson for transitions to discrete states. (auth)

**20708** IMPACT IONIZATION IN THE PROTON–H-ATOM SYSTEM. II. ELECTRONIC STATES AND TRANSITION ELEMENTS. Levy II, Hiram (Massachusetts Inst. of Tech., Cambridge); Thorson, Walter R. Phys. Rev., 181: 244-52(May 5, 1969).

Paper I of this series describes the calculation of the direct impact ionization cross section $\sigma_1(\epsilon)$ for low-energy proton–hydrogen-atom collisions, where an adiabatic description is essentially correct for the initial channel. To calculate this cross section it is necessary to compute Born–Oppenheimer continuum wave functions and evaluate the matrix elements of the transition operators connecting them to the ground-state components. Such electronic calculations and matrix elements are presented in this paper. The transition matrix elements are quite sensitive to the form chosen for the "electron translation factor." Present calculations have removed most of the large error appearing in perturbed stationary states (pss) theory due to neglect of this factor. The computed transition elements presented in this paper should lead to values for $\sigma_1(\epsilon)$ accurate to perhaps 30%; estimated remaining error is due to spurious long-range effects that can be removed by improvement of the translation factor. Further computation making such improvements is in progress. (auth)

**20709** IMPACT IONIZATION IN THE PROTON–H-ATOM SYSTEM. III. ELECTRON TRANSLATION FACTOR AND TRANSITION OPERATORS. Levy II, Hiram (Massachusetts Inst. of Tech., Cambridge); Thorson, Walter R. Phys. Rev., 181: 252-6(May 5, 1969).

To meet asymptotic boundary conditions, the scattering wave function for an atomic collision must include a kinematic factor representing transport of an electron attached to a moving heavy particle. For slow collisions this factor grossly affects the inelastic transition operator and its matrix elements. The general conditions the factor must satisfy are discussed. Matrix elements for impact ionization are especially sensitive to the choice of the factor, and computed results obtained with several choices are described briefly. A heuristic criterion for systematic improvement of the factor is discussed. (auth)

**20710** PRODUCTION OF METASTABLE MERCURY ATOMS BY ELECTRON IMPACT. Borst, Walter L. (Univ. of California, Berkeley). Phys. Rev., 181: 257-63(May 5, 1969).

Excitation of Hg atoms by electron impact, particularly into metastable states, was studied in the energy range 4 to 15 eV. The excitation function for the $6^3P_2$ metastable state (5.46 eV) was measured from threshold up to 8.5 eV. The absolute cross-sectional scale for this state was calibrated by monitoring slow inelastically scattered electrons near threshold. The cross section had a maximum value of $3.2 \times 10^{-16}$ cm$^2$ ± 25% (rms) at 5.75 eV and dropped to half this value at about 8 eV. An electron beam of 0.1-eV half-width was produced by the Retarding Potential Difference (RPD) method. Excited atoms were detected by electron ejection from a tungsten surface. The secondary-electron yield for the $6^3P_2$ state was typically $2 \times 10^{-4}$. Pronounced structure in the detector current with maxima at 9.00 and 9.60 eV was attributed to the $7^3P_1$ state (8.64 eV). It appears that the contribution of the $6p'^3D_3^0$ metastable state was minor. An upper limit of a few times $10^{-18}$ cm$^2$ was estimated for the maximum cross section of this state. Another region of structure in the total detector current occurred close to and above ionization threshold. Experimental evidence indicates that this structure was produced by long-lived autoionizing states. (auth)

**20711** ELECTRON TEMPERATURE DEPENDENCE OF RECOMBINATION OF $O_2^+$ AND $N_2^+$ IONS WITH ELECTRONS. Mehr, F. J.; Biondi, Manfred A. (Univ. of Pittsburgh). Phys. Rev., 181: 264-71(May 5, 1969).

A microwave-afterglow/mass-spectrometer apparatus, which employs microwave heating of the electrons, is used to determine the recombination coefficients, $\alpha(O_2^+)$ and $\alpha(N_2^+)$, of mass-identified ions with electrons as a function of electron temperature. From electron-density decay data taken under good "ion-tracking" conditions it is found that $\alpha(O_2^+)$ varies as $T_e^{-0.70}$ over the range $300°K \leq T_e \leq 1200°K$ [starting from a value $(1.95 \pm 0.2) \times 10^{-7}$ cm$^3$/sec at $T_e = 300°K$] and then varies as $T_e^{-0.56}$ between 1200 and 5000°K. In the nitrogen studies the "ion tracking" of the electron decay is less perfect, but $N_2^+$ remains the principal afterglow ion and $\alpha(N_2^+)$ is found to vary as $T_e^{-0.39}$ over the entire range $300°K \leq T_e \leq 5000°K$, starting from a value $(1.8^{+0.4}_{-0.4}) \times 10^{-7}$ cm$^3$/sec at $T_e = 300°K$. These results are compared with other laboratory determinations, results of theoretical calculations, and values inferred from analyses of ionospheric measurements. (auth)

**20712** ELECTRON TEMPERATURE DEPENDENCE OF RECOMBINATION OF $Ne_2^+$ IONS WITH ELECTRONS. Philbrick, J.; Mehr, F. J.; Biondi, Manfred A. (Univ. of Pittsburgh). Phys. Rev., 181: 271-4(May 5, 1969).

The electron-temperature dependence of the recombination of mass-identified $Ne_2^+$ ions with electrons is studied by means of a microwave-afterglow/mass-spectrometer apparatus employing microwave heating of the electrons. Under conditions such that the ion wall current "tracks" the volume electron-density decay, the electron-decay data indicate that $\alpha(Ne_2^+)$ decreases as $T_e^{-0.49}$ over the range $300°K \leq T_e \leq 4600°K$, starting at a value $(1.75 \pm 0.2) \times 10^{-7}$ cm$^3$/sec at $T_e = 300°K$. This value and this variation with $T_e$ are in good agreement with the results of other studies, all but one of which did not employ mass identification of the ions under study. (auth)

**20713** VELOCITY-DEPENDENT ORBITALS IN PROTON-ON-HYDROGEN-ATOM COLLISIONS. Schneiderman, S. B. (United Aircraft Research Labs., East Hartford, Conn.); Russek, A. Phys. Rev., 181: 311-21(May 5, 1969).

Requirements are outlined for a suitable set of dynamic orbitals for theoretical studies in collision problems. The effect of these upon the wave function, dynamic energy correction, and effective internuclear potential are all considered. It is shown that earlier forms suggested for this type of problem do not meet all required dynamic boundary conditions, principally because of their failure to recognize that physically, for moderate-speed collisions, the electron at times "belongs" to the "molecule" proper and not to either atom individually. The earlier orbitals also fail to make allowances for the reluctance of an electronic charge distribution to follow rapid rotation of an internuclear axis. These considerations suggest a new form of dynamic orbital, which, by remedying these deficiencies, automatically achieves complete orthonormality. The results of preliminary charge-transfer calculations with the new orbital basis are presented. (auth)

**20714** ELASTIC AND INELASTIC ELECTRON SCATTERING BY He AND Ne ATOMS IN THEIR GROUND STATES. Peixoto, E. M. A.; Bunge, C. F.; Bonham, R. A. (Indiana Univ., Bloomington). Phys. Rev., 181: 322-8(May 5, 1969).

A study of elastic and inelastic scattering of electrons by He and Ne atoms in their ground states is made within the framework of the first Born approximation. For the elastic case a partial-wave analysis is also carried out. Properly correlated configuration interaction wave functions, and also Hartree–Fock wave functions, are used throughout. It is shown that for an accurate description of both elastic and inelastic scattering, a correlated wave function is essential. A table of elastic and inelastic electron scattering factors for the elements studied is given. (auth)

**20715** CLASSICAL ION MOTION IN ELECTROSTATIC DIPOLE FIELDS. Chandrasekaran, T.; Wilkerson, T. D. (Univ. of Maryland, College Park). Phys. Rev., 181: 329-37(May 5, 1969).

The classical unbound motion of an ion in an electrostatic dipole field $V = k \cos \theta \; r^2$ has been solved analytically and displays many very interesting features. In addition to total energy E and the azimuthal angular momentum $p_\phi$, $\alpha = p_\theta^2 + p_\phi^2 \sin^2 \theta + 2mke \cos \theta$ is also conserved. For all potentials of the form $F(\theta, \phi)/r^2$, $r^2$ is a symmetric quadratic function of time. For the fixed point dipole problem, $r^2(\tau) = 2E\tau^2/m + \alpha/2Em$; both E, $\alpha > 0$ for scattering orbits. For meridian plane motion ($p_\phi = 0$), the polar angle $\theta(\tau)$ is expressed in terms of Jacobian elliptic functions. Special attention is paid to turning points and to the specification of asymptotic orbits via energy, impact parameter b, and initial asymptotic angle $\theta_i = \theta(-\infty)$. Representative meridian plane orbits are shown and scattering angle is discussed as a function of $Eb^2$. For general nonplanar scattering ($p_\phi \neq 0$), limitations on the range of $\theta$ arise, as in the related problems of the spherical pendulum and symmetric heavy top. Azimuthal angle $\phi(\tau)$ is expressed as an incomplete elliptic integral of the third kind: $\pi(x,\beta) = \int_0^x du/(1 - \beta^2 \, sn^2 u)$, which can usefully be expressed in terms of theta functions. Thus the simplest case of classical ion–dipole scattering is already quite complex as regards solution by analytical means. (auth)

**20716** EXCITATION OF THE $n^1S$ STATES OF HELIUM BY PROTON IMPACT AND THE $n^{-3}$ RULE. Oldham, William J. B. Jr. (Manned Spacecraft Center, Houston, Tex.). Phys. Rev., 181: 463-4(May 5, 1969).

Recently calculated cross sections for the excitation of the $n^1S$ (n = 4 to 7) states of helium displayed as a function of $n^{-3}$ show an anomalous behavior of the $7^1S$ cross sections. This anomalous behavior has been traced to the 40-term correlated wave function used to represent the $7^1S$ state. A more accurate 40-term wave function has been used to recalculate the $7^1S$ excitation cross sections. The cross sections are changed only by about 5%, but they now fit the pattern as far as the $n^{-3}$ dependence is concerned. (auth)

**20717** AN ANALYSIS OF TOTAL GAMMA RAY CROSS SECTIONS IN THE ENERGY REGION FROM 40 TO 80 keV IN Cu, Sn, W, AND Pb. Raja Rao, M.; Parthasaradhi, K. (Andhra Univ., Waltair, India). Aust. J. Phys., 22: 131-2(Feb. 1969).

Mean values of the total gamma cross sections for Cu, Pb, Sn, and W at gamma energies of 40, 50, 60, 70, and 80 keV were derived from the available experimental data in order to make a comparison with theoretical estimates. The mean values are in excellent agreement with theoretical estimates obtained by adding theoretical values for the photoelectric and scattering cross sections. (D.C.W.)

**20718** COHERENCE RADIATION OF ATOMS AND ATOMIC NUCLEI IN EXTERNAL MAGNETIC AND ELECTRIC FIELDS. Hanle, W.; Pepperl, R. (Univ., Giessen, Ger.). Acta Phys. Pol., 34: 675-91(Oct. 1968). (In German).

Various methods of coherent excitation of atomic energy levels that are used in level-crossing, antilevel-crossing, and and optical double resonance experiments are compared. Angular correlations perturbed by external fields in nuclear physics are compared with zero-field-level crossing in atomic physics. Also, the influence of collisions on the coherence between atomic states is reported. (auth)

**20719** SPIN POLARIZATION OF LOW-ENERGY ELECTRONS SCATTERED FROM MOLECULES. I. IODINE AND ETHYL IODIDE. Hilgner, Wilfried; Kessler, Joachim (Univ., Karlsruhe, Ger.). Z. Phys., 221: 305-23(1969). (In German).

Cross sections and spin polarization of low-energy electrons scattered by $I_2$ and $C_2H_5I$ molecules were measured in the energy range from 200 to 600 eV and angular range from 30 to 150°. At the same time, several authors made calculations of cross sections and polarizations based on the following assumptions: The molecule consists of free atoms that are independent of each other (the influence of binding is negligible) and scattering of an electron does not occur more than once within the molecule. The agreement between theory and experiment in a wide angular range justifies these assumptions for the present problems. Polarization values lower than the theoretical ones were measured only at scattering angles at which the theory predicts very narrow and high values of the spin polarization. Qualitative arguments show that

intramolecular scattering very likely is responsible for the deviations found between theoretical and experimental polarization peaks. By means of the polarization of the scattered intensity one can easily decide how much of the scattered intensity comes from one part of the molecule and how much comes from the other part. (auth)

**20720** SPIN POLARIZATION OF LOW-ENERGY ELECTRONS SCATTERED FROM MOLECULES. II. BISMUTH TRIPHENYL AND BENZENE, WATER, CARBON TETRACHLORIDE. Hilgner, Wilfried; Kessler, Joachim; Steeb, Ernst (Univ., Karlsruhe, Ger.). Z. Phys., 221: 324-32(1969). (In German).

Cross sections and spin polarization of low-energy electrons scattered by $Bi(C_6H_5)_3$, $C_6H_6$, $H_2O$, and $CCl_4$ molecules were measured in the energy range from 60 to 1600 eV and angular range from 30 to 150°. The independent-atom model gives good agreement between measured and calculated cross sections and spin polarization at higher energies. At lower energies, the polarization of electrons scattered from $Bi(C_6H_5)_3$ indicates the amount of screening of a central atom in a molecule by the surrounding radicals. In addition, the polarization measurements show that electrons scattered from molecules which consist of atoms with low atomic numbers are virtually unpolarized. (auth)

**20721** CURRENT UNCERTAINTIES IN THE DETERMINATION OF THE FUNDAMENTAL CONSTANTS. Cohen, E. Richard (North American Aviation Science Center, Thousand Oaks, Calif.). pp 478-92 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28-September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

A survey is presented of recent data on the determination of fundamental physical constants. The magnetic moment and gyromagnetic ratios of the proton and the hydrogen fine structure constant are discussed in detail. (J.W.R.)

**20722** DETERMINATION OF e/h USING THE A. C. JOSEPHSON EFFECT. Langenberg, D. N. (Univ. of Pennsylvania, Philadelphia); Parker, W. H.; Taylor, B. N. pp 439-60 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28-September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

The current status of a series of experiments attempting to determine the fundamental constant e/h using the ac Josephson effect is reported. The theoretical basis for the experiments is discussed and some preliminary experiments supporting the validity of the method are described. (J.W.R.)

**20723** THRESHOLD LAW FOR ELECTRON IMPACT EXCITATION OF ns-n's TRANSITIONS IN ATOMS. Damburg, R. J. (National Bureau of Standards, Boulder, Colo. Univ. of Colorado, Boulder). J. Phys., B (London), 2: 145(Jan. 1969).

A correction to the Wigner threshold law due to long-range interaction for the excitation of ns-n's transitions in atoms is given. (auth) (UK)

## Cosmic Radiation

*Refer also to abstracts 20629, 20650, 20818, 21040, and 21067.*

**20724** (N-68-36131) FLUCTUATION ORIGIN OF COSMIC RADIATION. Wayland, J. R. (Maryland Univ., College Park. Dept. of Physics and Astronomy). Aug. 1968. 21p. (NASA-CR-97142; TR-873). CFSTI.

The origin of cosmic radiation was investigated in terms of a sudden injection of particles in time, momentum, and space. The appropriate boundary conditions for the various regions through which the particles pass were used. With all of the acceleration within a turbulent region, one finds that the observed spectrum is explained by a continuous deceleration in which statistical fluctuations dominate. This is contradictory to the usual assumptions in which fluctuation does not play an important part. One finds that the exponent of the power law spectrum has a weak momentum dependencey as $\gamma = 0.057 \ln (P/P_0) + 0.67$. (auth) (STAR)

**20725** COSMIC-RAY LIFE AND STOCHASTIC NATURE OF THE GALACTIC MAGNETIC FIELD. Jokipii, J. R.; Parker, E. N. (Univ. of Chicago). Astrophys. J., 155: 799-806(Mar. 1969).

It is pointed out that the observed mean life for cosmic rays of $\sim 10^8$ yrs is difficult to account for in conventional models of the galactic magnetic field. A stochastic model of the interstellar magnetic field is proposed, and is shown to provide a natural explanation of the cosmic-ray lifetimes. The random walk of magnetic lines of force, deduced from the observed turbulent motions of the gas and also from observations of the polarization of starlight, leads to rapid motion of the cosmic-ray particles normal to the plane of the galactic disk. (auth)

**20726** EFFECTS OF THE TERRESTRIAL MAGNETIC FIELD ON COSMIC RAYS. Conforto, A. M. (Univ., Rome). Nuovo Cim., Suppl., 6: 887-912(1968). (In Italian).

The dipole approximation of the terrestrial magnetic field is summarized. Measurements of the magnetic field over the Earth's surface have shown that the dipole model is only a first approximation and it is necessary to take into consideration asymmetries presented by the real field. The longitudinal effects, and the cosmic-ray equator, and the source rigidity must also be considered. Results obtained by various experimental workers on the true magnetic field are tabulated and discussed. The effects of the external source are also discussed in detail. (J.S.R.)

**20727** MODULATION OF GALACTIC COSMIC RAYS OF ENERGIES ABOVE 1 GeV. Bachelet, F. (Univ., Rome. GIFCO, Rome). Nuovo Cim., Suppl., 6: 1002-23(1968). (In Italian).

The problematics of the propagation of galactic cosmic rays across the space controlled by solar activity and, in particular, the role of the information obtained with the registration on Earth, are briefly summarized. In this respect, some essential experimental problems are discussed. (tr-auth)

**20728** MONITORING RECORDER OF COSMIC RAYS. Shafer, Yu. G.; Yarygin, A. V. (Inst. of Cosmophysical Investigations and Aeronomy, Novosibirsk, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 609-12(1968).

Translated from Geomagn. Aeron., 8: 765-9(1968).

An instrument for use on satellites as a monitoring recorder of cosmic-ray intensity in the energy interval sensitive to the geomagnetic field is described. (auth)

**20729** STUDY OF THE ENERGY SPECTRUM OF 11-YEAR VARIATIONS IN COSMIC-RAY INTENSITY ACCORDING TO MEASUREMENTS IN THE STRATOSPHERE. Stozhkov, Yu. I.; Charakhch'yan, T. N. (Lebedev Inst. of Physics, Moscow. Moscow State Univ.). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 500-4(1968).

Translated from Geomagn. Aeron., 8: 624-9(1968).

The energy spectrum of 11-year variations in the primary component of cosmic rays is investigated from data on the relative variation of cosmic-ray intensity, $\Delta N/N$, at various depths in the atmosphere (10 to 300 g/cm$^2$). About 10,000 stratospheric measurements made from 1959 through 1965 are used. The results obtained show that the energy spectrum of secular variations did not change from 1959 through 1963. For an energy spectrum of variation of form $1 - \exp(A/vp^{\alpha})$ the value of the exponent $\alpha$ was close to 0.5 over this period. Significant changes in the spectrum were observed in the vicinity of the solar activity minimum. In the first half of 1964, $\alpha \approx 1$ and in 1965, $\alpha \approx 0$. The data obtained relate to primary particles of hardness $p \leq 5$ to 8 BV. For particles of hardness $p > 8$ to 10 BV the parameter $\alpha = 1.5$ for 1959. (auth)

**20730** NEUTRON DISTRIBUTION IN THE ATMOSPHERE WITH ALLOWANCE FOR DENSITY VARIATION. Pal'vanov, V. Ch.; Pushtarik, V. A.; Strelkov, A. S. (Inst. of Terrestrial Physics, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 505-10(1968).

Translated from Geomagn. Aeron., 8: 630-7(1968).

The kinetic equation of the distribution of radiation with a spherical scattering index in the atmosphere is solved with allowance for exponentially changing density. Solutions are obtained for age and diffusion approximations for a point source and a plane source. The results show that the spatial distribution of neutrons in the atmosphere above 15 km differs markedly from the distribution in a medium with constant density. (auth)

**20731** ACCELERATION OF HIGH-ENERGY COSMIC RAYS BY PULSARS. Gunn, James E.; Ostriker, Jeremiah P. (Princeton Univ., N. J.). Phys. Rev. Lett., 22: 728-31(Apr. 7, 1969).

Very large quantities of low-frequency electromagnetic radiation will be produced by the rotating, magnetic, neutron stars favored for pulsar models. It is shown that this radiation will accelerate particles injected into the wave field to energies in excess of $10^{18}$ eV (adopting parameters derived from the Crab object), that the spectral dependence accords with cosmic-ray observations, and that the total energy available is consistent with the observed density of these very high-energy particles. The maximum energy a proton can attain by this mechanism is of order $(e^2/Gm_p^2)^{\frac{1}{2}} \times$ (rest mass) or $\approx 10^{21}$ eV. (auth)

**20732** COSMIC RAYS AND THE DYNAMICS OF THE SOLAR WIND. I. Dorman, I. V.; Dorman, L. I. (Inst. of Terrestrial

Magnetism, Ionosphere, and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 652-6(1968).

Translated from Geomagn. Aeron., 8: 817-21(1968).

In the study of the propagation of cosmic rays in interplanetary space, the solar wind is regarded as given and independent of cosmic-ray intensity. It is demonstrated that a rigorous analysis of the problem requires that allowance be made for the reciprocal effect of cosmic rays on solar plasma fluxes, achieved through magnetic fields. An integro-differential equation is derived that describes the interaction between cosmic rays and the solar wind with allowance for the modulation of the intensity and deceleration of the wind by cosmic rays. (auth)

**20733** DATA ON MAGNETIC INHOMOGENEITIES IN INTERPLANETARY SPACE ACCORDING TO MEASUREMENTS OF SOLAR AND GALACTIC COSMIC RAYS. Charakhch'yan, A. N.; Charakhch'yan, T. N. (Lebedev Inst. of Physics, Moscow. Moscow State Univ.). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 657-62(1968).

Translated from Geomagn. Aeron., 8: 822-9(1968).

The time of establishment of the amplitude of modulation of cosmic rays under the effect of solar activity is investigated. Instances are found when cosmic-ray intensity gradually increases in the stratosphere after the decline of solar activity, and a new stationary level is established within two months. The time of establishment of the amplitude of cosmic-ray modulation in interplanetary space was 40 days in 1961, 60 days in 1963, and 80 days in 1964. According to the results obtained, the rate of propagation of magnetic inhomogeneities that modulate galactic cosmic rays in interplanetary space was $u_0 \approx 5 \times 10^7$ cm/sec in 1961 and $u_0 \approx 3 \times 10^7$ cm/sec in 1964. The radius of the sphere, r, around the Sun within which cosmic rays are modulated depends little on solar activity and is 10 to 15 au. The flux density of magnetic clouds does not show any marked dependence on the distance to the Sun to ~10 au. (auth)

**20734** COUPLING COEFFICIENTS FOR THE CHARGED COMPONENT OF COSMIC RAYS IN THE STRATOSPHERE. Stozhkov, Yu. I.; Charakhch'yan, T. N. (Lebedev Inst. of Phys., Moscow. Moscow State Univ.). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 663-6(1968).

Translated from Geomagn. Aeron., 8: 830-4(1968).

The coupling coefficients were computed for the global and vertical fluxes of the charged component of cosmic rays measured in the stratosphere with RK-1 and RK-2 radiosondes. The coupling coefficients were determined for various atmospheric pressures in the interval 10 to 400 g/cm$^2$ for the second half of 1964. (auth)

**20735** GAMMA QUANTUM SPECTRA IN ENERGY RANGE FROM $10^{11}$ TO $10^{13}$ eV IN THE UPPER ATMOSPHERE. Apanasenko, A. V.; Baradzei, L. T.; Kanevskaya, E. A.; Rykov, V. V.; Smorodin, Yu. A.; Solov'ev, M. V. (Lebedev Inst. of Physics, Moscow). Izv. Akad. Nauk SSSR, Ser. Fiz., 32: 374-7(Mar. 1968). (In Russian).

Data obtained on vertical flux of $\gamma$ quanta in the upper atmosphere at 200 g $\cdot$ cm$^{-2}$ indicated the dip of energy spectra of $\gamma$ quanta and, consequently, of the $\pi^0$ mesons generated in the atmosphere does not differ from the dip of the spectra of nucleons generating $\pi$ mesons. Thus, generation of pions with energy proportional to the nuclear energy takes place in a wide range of energies (from $10^{10}$ to ~$10^{14}$ eV). The analyzed data on the cascades accompanying $\gamma$ quanta with energies over $3 \times 10^{12}$ eV showed that 38 of the 54 $\gamma$ quanta are in the cascades with three and more quanta, 5 are in the cascades with $\gamma$ quantum pair, and 11 with a single $\gamma$ quantum. This indicated that, in one third of the cases, $\gamma$ quanta are generated in the events in which the energy of the second $\pi^0$ meson differs more than fivefold from the energy of the emitted $\pi^0$ meson. In the other cases, $\pi$ mesons have identical energy. The ratio of $\gamma$ quanta appearing in pairs to the number of single $\gamma$ quanta enables one to determine the processes generating single $\gamma$ quanta. (R.V.J.)

## Direct Energy Conversion

**20736** (AGARDograph-122) SELECTED TOPICS IN ELECTROFLUID DYNAMIC ENERGY CONVERSION. Lawson, Maurice; Wattendorf, Frank (eds.) (Advisory Group for Aerospace Research and Development, Paris (France)). Dec. 1968. 264p.

The information presented is based largely on presentation of EFD research or related research being conducted in each NATO nation represented at the Electrofluid Dynamic "Workshop" Conference which was held at the Aerospace Research Laboratories, Wright-Patterson Air Force Base, Ohio, May 23-25, 1966; subsequently, many of the papers were updated at an editorial conference held at AGARD, Paris, October 30-31, 1967, while others still later were updated by correspondence. The papers are included. (auth)

**20737** (INR-941) SPACE CHARGE IN THE MHD GENERATOR CHANNEL. Celinski, Z. (Institute of Nuclear Research, Warsaw (Poland)). 1968. 34p. Dep.

The conditions of the space charge formation in the MHD generator channel are described. The space charge is formed due to nonuniformity of the gas parameters and magnetic induction vector. The fundamental mathematical expressions are derived and physically explained. In the considerations the steady plasma flow is assumed. (auth)

**20738** (N-68-31492) APPLIED THERMIONIC RESEARCH. Quarterly Progress Report, March 4-June 4, 1968. Gyftopoulos, E. P.; Hatsopoulos, G. N.; Holly, F.; Lieb, D.; Rufeh, F.; (and others) (Thermo Electron Engineering Corp., Waltham, Mass.). Contracts NAS7-100; JPL-952184. 32p. (NASA-CR-95987; TE-4092/3-183-68; QPR-2). CFSTI.

For Jet Propulsion Lab., Pasadena, Calif.

Thermochemical data on the oxidation products of cesium studied by differential thermal analysis indicated a rather complex mixture and observed peaks that could be attributable to $Cs_3O$, CsOH, and $Cs_2O_3$. Rigorous definitions were given of the electronegativity of neutral and ionized atoms and of atomic orbitals that are consistent with the rules of the statistics of the ensembles and the quantum-mechanical picture of atomic species. Dependence of the internal voltage drop on ion richness ($\beta$) and cesium pressure (P) at constant values of Pd, where d is the interelectrode spacing was made with a variable-spacing, guard-ring converter with single tungsten emitter and molybdenum collector. It is suggested that voltage drop is a decreasing function of P at constant values of Pd and $\beta$, and a decreasing function of $\theta$ at constant values of P and d. To obtain data on in-pile test converters, a variable-spacing, guard-ring converter with fluoride vapor-deposited tungsten emitter and molybdenum collector was constructed. Heat treatment caused changes in microstructure, not necessarily accompanied by pole figure changes, of the vapor-deposited tungsten emitters. (STAR)

**20739** (N-68-37259) DESIGN AND PRELIMINARY OPERATION OF THE LEWIS MAGNETOHYDRODYNAMIC GENERATOR FACILITY. Nichols, Lester D.; Morgan, James L.; Nagy, Lawrence A.; Lamberti, Joseph M.; Ellson, Robert A. (National Aeronautics and Space Administration, Cleveland, Ohio. Lewis Research Center). Oct. 1968. 26p. (NASA-TN-D-4867). CFSTI.

The closed loop facility has been designed to study the feasibility of an argon-cesium MHD generator. The construction details, performance, and some preliminary research data are discussed. The facility has operated for several hours at the following conditions: argon flow rate, 1.8 kg/sec; Mach number, 0.3 to 0.5; stagnation temperature, 2100°K. Thus far, open-circuit voltages equal to 60% of theoretical value (at 50 V) were measured. In addition, short-circuit currents up to 0.8 A (per electrode pair) were measured. This is in agreement with the calculated value using equilibrium conductivity. Leakage currents prevented better performance. (auth) (STAR)

**20740** (NP-17800) INSTABILITY OF HALL MHD GENERATORS TO MAGNETO-ACOUSTIC WAVES. Research Report 323. Fishman, Frank J. (Avco-Everett Research Lab., Everett, Mass.). Feb. 1969. 39p.

It is known that magneto-acoustic waves propagating antiparallel to a steady electric current in a dense, weakly ionized gas may exhibit substantial growth. In this paper, the stability of a Hall MHD generator with supersonic flow to disturbances of this type is assessed. A proper boundary-value problem is solved, with full consideration of the load circuit, which may serve as a feedback path for wave energy. It is shown that this feedback may lead to instabilities even under conditions such that the wave growth (as evaluated by earlier investigations) is slow. Disturbances with a period comparable to the flow time (channel length/fluid velocity) are the principal contributors to the instability; the spatial variation of these disturbances is far from sinusoidal. The control of machine instabilities by electrical filters in the external (load) circuit is described. (auth)

**20741** THE DIRECT CONVERSION OF HEAT INTO ELECTRICITY: MAGNETOHYDRODYNAMIC CONVERSION AND ELECTROGASDYNAMIC CONVERSION. Greaves, C. (Rugby Coll. of Engineering and Tech., Eng.). Phys. Educ., 4: 40-3 (Jan. 1969).

A brief review is given under the following heading: Basic principles of MHD electrical power generation; the open-cycle MHD conversion system; the closed-cycle MHD conversion system; practical progress in MHD conversion and future possibilities; basic principles of EGD electrical power generation;

practical progress of EGD conversion and future possibilities. (UK)

**20742** A SHOCK TUBE STUDY OF NONEQUILIBRIUM MHD POWER GENERATION. Mori, Yasuo (Tokyo Inst. of Tech.); Kawada, Haruo; Imani, Kazutake. Bull. JSME (Jap. Soc. Mech. Eng.), 11: 679-90(Aug. 1968).

Experiments with a shock tube for inert-gas MHD power generators utilizing nonequilibrium ionization are reported. By preheating the whole low-pressure chamber of the shock tube, it was possible to seed sufficient amounts of K to the working gas and to realize the conditions required for MHD power generation. The first type of generator made use of an induced electric field, resulting from the interaction of gas flow and magnetic field, to obtain nonequilibrium ionization. Although the steady-flow experiments reported so far have not yielded the high electrical conductivities predicted by nonequilibrium theory, the results of detailed measurements in the present device were fairly close to those predictions. The reason for this discrepancy is considered to be the absence of appreciable boundary effects and flow instability in experiments of such short durations. The unfavorable effect of small amounts of impurities on the generator performance was also demonstrated. The second type of nonequilibrium MHD generator utilizing metastable nitrogen was similarly tested, and was found to be a promising alternative. (BBB)

**20743** TWO-DIMENSIONAL CURRENT DISTRIBUTIONS IN FARADAY-TYPE MHD ENERGY CONVERTERS OPERATING IN THE NONEQUILIBRIUM CONDUCTION MODE. Lengyel, Lajos L. (Inst. fuer Plasmaphysik, Munich). Energy Convers., 9: 13-23 (Mar. 1969).

Relaxation effects associated with finite ionization and recombination rates have been examined previously, where the asymmetry of the resulting current distribution as well as the nonunique relation between the electron temperature and the local current density were considered. This study is extended, the various factors affecting the current distribution in the plane normal to the magnetic field being considered separately here. The distributions of the electrostatic potential and electric current in the plane normal to the flow direction are considered under open-circuit conditions. Velocity and gas temperature profiles prescribed in the normal cross section of the duct are considered, and the corresponding field distributions computed with allowance for the dependence of the electric conductivity on the electron and gas temperatures. (TSS) (UK)

**20744** PROSPECTS OFFERED BY ELECTRIC PROPULSION IN THE NEAR FUTURE. Surugue, J.; Fabri, J.; Le Grives, E. (ONERA, Chatillon-sous-Bagneux, France). pp 209-24 of Problems of Propulsion and Re-entry. Lunc, Michael (ed.). New York, Gordon and Breach, Inc., 1967. (In French).

From 17th International Astronautical Congress, Madrid. See CONF-661051.

The possible uses of various propulsion devices (thermoelectric, electromagnetic, and electrostatic) in association with nuclear sources for cosmonautic applications are discussed. (TSS)

**20745** ENGINEERING ASPECTS OF ELECTROGASDYNAMICS. Gourdine, M. C. (Gourdine Systems, Inc., Livingston, N. J.). Trans. N. Y. Acad. Sci., 30: 804-14(Apr. 1968).

The history, principles, and applications of electrogasdynamics (EGD) are reviewed. There are two broad areas of application for the elementary EGD energy conversion channel: one in which the EGD force opposes the flow and power is extracted from the flow in the form of electricity (these are EGD generators); and the other in which the EGD force aids the flow and power is put into the flow to compress it (these are EGD compressors). Each of these applications is discussed as shown by a schematic diagram of an elementary EGD generator, ions are injected into the flow by a corona-attractor electrode assembly in which the attractor electrode (ring) is biased negative with respect to the corona electrode (needle), and positive ions leaving the needle are blown downstream to the collector electrode. These ions then return to ground through the external load. This generator is analogous to the Van de Graaff generator, except that the belt is replaced by a fast moving gas stream. The Gourdine generator (Mark I) is shown. In this generator the major loss of efficiency is due to friction on the walls, because the flow must be supersonic to form the droplets. Some areas where EGD will find eventual use are: central station power plants; high-energy particle accelerators; electron beam welding; x-ray machines for process irradiation of foods, metals, and plastics; air pollution control; water desalination; gas compression; and possibly, in the distant future, jet engines with no moving parts that can operate efficiently throughout the entire flight corridor from ground to satellite orbit. (BBB)

**20746** MHD: WHERE AT AND WHERE TO? Brogan, Thomas R. Astronaut. Aeronaut., 6: 48-9; 52-3(Nov. 1968).

The design, construction, and operation of MHD pilot plants which duplicate, insofar as possible, in all respects except size, the essential features of full-scale MHD plants, are discussed. A national program of MHD pilot plants will likely cost $100 million over a period of 5 to 6 yr. Initiation of multiple pilot-plant programs in the near future would make it possible to have full-scale MHD prototype units on the line in the late late 1970's. Some industrial applications for MHD which closely resemble commercial base-load power generation are considered. The rocket-driven MHD generator (RDG) takes most direct advantage of the similarity between the MHD generator and the rocket engine. A simple combination of an MHD generator and rocket engine using more or less conventional propellants can generate very large amounts of power for limited durations with simple, inexpensive, and lightweight equipment. One generator has achieved a maximum power output of 31 MW, and another designed for high-voltage output and as a prototype for a much larger unit, has achieved 16 MW. A lightweight 2-MW RGD unit is under development. Since the chemically fueled MHD generator needs an oxidizer, the use of fossil-fuel fired MHD outside the atmosphere in space is limited to the special application of a high-energy burst for a short period, i.e., the RGD. For extended power generation in space, there are 2 possibilities, both using a nuclear reactor as the heat source: the closed Brayton cycle and the liquid-metal MHD cycle. Before the closed MHD Brayton cycle can be given serious consideration for application in space, many problems need to be solved. In the Snap 50–Spur program, a liquid-metal-cooled reactor was to deliver saturated vapor to a turbine at 1300 to 1350°K. The liquid-metal MHD concept is, in principle, compatible with reactors of the type developed for Snap 50. (BBB)

**20747** COAGULATION IN BARIUM OXIDE–ARGON SUSPENSIONS POSTULATED AS CLOSED -CYCLE MAGNETOHYDRODYNAMIC WORKING FLUIDS. Waldie, B.; Fells, I. (Univ. of Newcastle upon Tyne, Eng.). J. Phys., D (London), 2: 453-6 (Mar. 1969).

An estimate was made of the significance of coagulation in barium oxide–argon suspensions postulated as working fluids for closed-cycle magnetohydrodynamic generators. Assuming an initial particle diameter of 0.05 μm and a barium oxide to argon weight ratio of 0.1, coagulation would cause the mean particle diameter to increase to at least 0.26 μm during a single circuit round an MHD steam turbine power station with a net output of 500 MW. According to previous theory, the electrical conductivity of the suspension would then fall to an unacceptable value. The problem would be expected to occur also with suspensions of other solid thermionic emitting particles. (auth) (UK)

**20748** A REVIEW OF FLUID MECHANICAL AND RELATED PROBLEMS IN MHD GENERATORS. Broadbent, E. G. (Royal Aircraft Establishment, Farnborough, Eng.). Progr. Aeronaut. Sci., 9: 215-327(1968).

An elementary introduction to MHD power conversion is presented in Part I, bearing in mind the concepts from incompressible MHD channel flow discussed by Gold. Some of the latest developments are reviewed in Part II, based on the papers presented at the Salzburg meeting in July 1966. (auth)

**20749** CASCADED THERMIONIC CONVERTER. Danko, Joseph S.; McCoy, Peter J. (to Westinghouse Electric Corp.). U. S. Patent 3,430,079, Feb. 25, 1969. Filed Dec. 12, 1961.

The thermionic converter described includes an elongated insulating casing, a plurality of supporting members within the casing and spaced along the length, and a plurality of generally tubular, conductive one-piece anode–cathode members mounted on the supports. Each of the anode–cathode members includes an enlarged tubular anode portion and a reduced integral tubular cathode portion mounted in tandem. The supports are spaced such that the cathode portion of at least one of the anode–cathode members is positioned within the anode portion of an adjacent anode–cathode member to form a plurality of series-connected thermionic cells along the interior length of the casing. Heat-emitting means are juxtaposed to the cathode portions in a heat-transfer relationship. Circuitry is provided for connecting the series-connected cells to external electric circuitry. (TSS) (Offic. Gaz.)

**20750** THERMIONIC CONVERTER. Harbaugh, Willis E. (to United States Atomic Energy Commission). U. S. Patent 3,426,221. Feb. 4, 1969. Filed Mar. 29, 1966.

The thermionic generator described has a radioisotope-heated emitter and a controlled temperature collector adjacent to it. Equal-area-absorber means are specifically located near the collector and emitter at different temperatures for the interchange of alkali metal vapor between them as the emitter temperature

decreases, because of the radionuclide decay of the radioisotope heat source. (TSS) (Offic. Gaz.)

**20751** PLANT FOR THE DIRECT CONVERSION OF HEAT INTO ELECTRIC ENERGY. Pereletov, Ivan Ivanovich (to Moskovskii Energeticheskii Institut). British Patent 1,146,041. Mar. 19, 1969. Filed Mar. 22, 1966.

The chief disadvantage of existing MHD plants is the low degree of regeneration of the heat of the exhaust gases. The plant described uses this disadvantage to obtain increased efficiency. The plant comprises an MHD generator and a combustion chamber, the outlet of which is connected to the inlet of the generator; the generator exhaust gases are used to heat a high-temperature air heater having an outlet connected to the combustion chamber inlet; an air compressor supplies air to the air heater inlet. A reactor heat exchanger is provided, having an inlet connected to the outlet of the MHD generator and another inlet connected to sources of steam and fuel, and having an outlet connected to the inlet of the combustion chamber of supply of the high-temperature products of an endothermic thermochemical process and another outlet connected to the inlet of the high-temperature air heater. The reactor/heat exchanger and the air heater may be connected in series or in parallel in the path of the exhaust gases. The exhaust gases may be fed from the reactor/heat exchanger and air heater to thermal power producing plant and thence to a low-temperature air heater arranged to heat the air fed from the compressor to the first air heater. The exhaust gases may also be fed to a low-temperature fuel heater arranged to heat the fuel being fed to the reactor/heat exchanger. The low-temperature air heater and fuel heater may be connected in parallel. (UK)

# Fluid Physics

*Refer also to abstracts 20736 and 20917.*

**20752** EXPERIMENTAL STUDY, IN THE REGION OF VALIDITY OF THE DARCY LAW, OF THE FLOW OF A VISCOUS AND ELECTROCONDUCTING LIQUID ACROSS AN INSULATING POROUS MILIEU IN THE PRESENCE OF A TRANSVERSE MAGNETIC FIELD. Vives, Charles; Daoud, Mohamed Ben (Laboratoire de Physique Industrielle, Alger, Algeria). Compt. Rend., Ser. A, B, 267: 958-60(Dec. 16, 1968). (In French).

The experiments verify the results obtained from the dimensional analysis. It was established that the permeability, the charge loss, and the Reynolds number vary linearly with the Hartmann number for values of the Hartmann number above 10 (tr-auth)

**20753** ON UNSTEADY HYDROMAGNETIC FLOW OF AN ELECTRICALLY CONDUCTING INCOMPRESSIBLE FLUID IN CONTACT WITH A HARMONICALLY OSCILLATING PLATE. Dube, S. K.; Khan, M. A. A. (Lucknow Univ., India). Bull. Cl. Sci., Acad. Roy. Belg., 54: 732-44(1968).

The flow of a viscous electrically conducting incompressible liquid over an infinite conducting plate has been analysed when the plate is harmonically oscillating and an oscillating current sheet is imposed on the plate. The Laplace-transform technique is used in determining the motion of the liquid. Cases when the plate is at rest or when the applied magnetic field is equal to zero have also been discussed. (auth)

**20754** ELECTRIC ARC IN A TRANSVERSE MAGNETIC FIELD: A THEORY FOR LOW POWER GRADIENT. Lord, W. T. (Royal Aircraft Establishment, Farnborough, Eng.). J. Fluid Mech., 35: 689-709(Mar. 10, 1969).

A uniform electric arc column is held at rest against an imposed low-speed flow perpendicular to its length by an applied magnetic field transverse to both the arc and the flow. The situation is represented mathematically by two regions separated by an isothermal boundary, the arc periphery, across which certain gas properties change discontinuously. It is assumed that the arc has low power gradient so that the Nusselt number is small compared with unity. The Reynolds number is then small also and the methods of the theory of flow at low Reynolds number are used to obtain solutions for the temperature, magnetic field, velocity and pressure inside and outside the arc. It is found that the periphery of the arc is a circle and its radius is determined by heat transfer. The flow near the periphery, and the drag of the arc, are found to depend on a final boundary condition at the periphery, the form of which is not yet clear. Several examples of possible flow patterns are given, and it is shown that the arc may be likened to a slippery porous body for which the slipperiness and porousness are governed by the final boundary condition. The electric and magnetic characteristics of the arc are derived and shown to be amenable to examination by experiment and to empirical extension for arcs of higher power gradient. (auth) (UK)

**20755** EFFECT OF WALL CONDUCTANCES ON CONVECTIVE MAGNETOHYDRODYNAMIC CHANNEL FLOW. Yu, C. P.; Yang, H. K. (Univ. of Colorado, Boulder, State Univ. of New York, Buffalo). Appl. Sci. Res. (The Hague), 20: 16-24(Jan. 1969).

The problem of convective magnetohydrodynamic channel flow in a vertical channel subjected simultaneously to an axial temperature gradient and a pressure gradient is examined when the thermal and the electrical conductance of the channel walls are arbitrary. The effects of wall conductances on the flow rate and heat transfer are found and discussed. When the vertical temperature gradient is negative, which is the case of heating from below, there exists a critical Rayleigh number at which the fluid becomes unstable. The critical Rayleigh number is also found as a function of the wall conductances. (auth)

**20756** MAGNETOHYDRODYNAMIC SLIP FLOW IN THE ENTRANCE REGION OF A PARALLEL-PLATE CHANNEL. II. Kikuchi, Kentaro. Kikai Shikenjo Shoho, 23: 24-35(Jan. 1969). (In Japanese).

An investigation of the combined influences of tensor conductivity, fluid viscosity, segmented electrodes and velocity slip on MHD flow in the entrance region of a parallel-plate channel has been carried out. Formulas for the flow velocity, pressure distribution, etc., are obtained in closed form by assuming an incompressible, two-dimensional fluid flow with constant properties. Numerical calculations are performed to show the influence of the Hall coefficient $\omega\tau$, the Hartmann number $H\alpha$, and the slip coefficient k on the flow. Due to the velocity profile distortions caused by changing $\omega\tau$ and k, unexpected results are obtained. (NSA of Japan)

**20757** STEADY FLOW OF A FINITELY CONDUCTING COMPRESSIBLE FLUID. Gundersen, Roy M. (Univ. of Wisconsin-Milwaukee, Milwaukee). Z. Angew. Math. Phys., 20: 34-58 (Jan. 25, 1968).

An investigation is made of the equations which govern the two-dimensional, steady flow of an ideal, inviscid, finitely conducting compressible fluid, subjected to a magnetic field with two components zero. In the cases where only the first (radial) or third (axial) component of the induction vector does not vanish, it is possible to find an integral of the induction equations, so that only a system of first-order partial differential equations is required to describe the flow. (M.H.R.)

**20758** THEOREM FOR EXISTENCE AND UNIQUENESS OF SHOCKS IN RELATIVISTIC MAGNETOHYDRODYNAMICS. Lichnerowicz, Andre. Compt. Rend., Ser. A, B, 268: 256-60(Jan. 27, 1969). (In French).

It is established that, under the hypotheses of relativistic compressibility, the general equations allow a theorem for existence and uniqueness, provided that certain inequalities concerning the velocities are satisfied. (tr-auth)

**20759** CURRENT DISTRIBUTION AROUND A NORMAL SHOCK IN AN MHD DUCT. Heywood, John B. (Central Electricity Research Labs., Leatherhead, Eng.). Plasma Phys., 11: 259-70(Apr. 1969).

The two-dimensional current and voltage distribution around a normal shock wave in an MHD duct is analyzed using a conformal transformation. Both continuous electrode and infinitely segmented-electrode boundary conditions are considered. It is shown that on the anode wall for continuous electrodes infinite current concentrations occur at the shock; for segmented electrodes the electric field becomes infinite at this point. The dissipation is computed for this latter case and is shown to be of order $\frac{1}{6}$th of the one-dimensional dissipation over a comparable volume. It is concluded that these current and field concentrations could cause electrode and insulator damage and that a theoretical analysis of a flow with a normal shock should make some allowance for two-dimensional effects. (auth) (UK)

**20760** HYDROMAGNETIC STABILITY OF DISSIPATIVE FLOW BETWEEN ROTATING PERMEABLE CYLINDERS. PART 2. OSCILLATORY CRITICAL MODES AND ASYMPTOTIC RESULTS. Chang, Tien Sun (North Carolina State Univ., Raleigh. Oak Ridge National Lab., Tenn.); Sartory, Walter K. J. Fluid Mech., 36: 193-206(Mar. 1969).

In considering the onset of instability of an electrically conducting fluid between rotating permeable perfectly conducting cylinders in an applied axial magnetic field, it is found that oscillatory axially symmetric modes occur at large values of Hartmann number, in addition to the usual stationary modes. Results are presented showing the effect of the oscillatory modes on the criterion of onset of instability. The asymptotic behavior of the stability criterion is considered in the limit of very large radial Reynolds number, and also in the limit where both the radial Reynolds number and the Hartmann number are large. (auth) (UK)

**20761** SOLUTIONS OF MHD BOUNDARY LAYER EQUATIONS WITH TRANSVERSE MAGNETIC FIELD AND ARBITRARY PRESSURE GRADIENT. Lalitha; Ramamoorthy, P. (National Aeronautical Lab., Bangalore, India). Proc. Indian Acad. Sci., Sect. A, 68: 251-64(Nov. 1968).

Certain solutions of magnetohydrodynamic boundary-layer equations for a flat plate with a transverse magnetic field fixed relative to the fluid were obtained using a power-series method given by Hassan. This power series solution has all the desirable qualities of the Görtler series and, in addition, its zeroth-order term that is governed by a nonlinear total differential equation can be given in closed form. The first-order term governed by a linear total differential equation was integrated numerically. The results are tabulated for various values of S, the interaction parameter. The results show a decrease in the boundary-layer thickness, with a consequent increase in skin friction as the strength of magnetic field is increased. (auth)

## Geophysics (Upper Atmosphere)

*Refer also to abstract 20726.*

**20762** SOURCES OF GEOMAGNETIC STORMS WITH GRADUAL COMMENCEMENT. Nesmyanovich, A. T. (Kiev Univ.). Solar Syst. Res. (USSR) (Engl. Transl.), 2: 40-5(Jan.-Mar. 1968).

The localization of the sources of particle streams responsible for storms with a gradual commencement was considered. An independent attempt was made at localizing corpuscular stream sources, using Mariner-2 data and other solar and geophysical data for the same period. On the basis of an analysis of the velocities of solar plasma for August 1962 to August 1963, it was concluded that low-latitude active regions, characterized by increased radio emission in the meter range and high flare activity, are sources of relatively fast geoeffective corpuscular streams. However, if an active region "quiet" in the meter range and without flares crosses the central meridian, a minimum of geomagnetic disturbance follows in 2 or 3 days. The flares or processes accompanying them apparently are responsible for acceleration of solar plasma to velocities considerably exceeding the velocity of hydrodynamic expansion. This creates corpuscular streams. The directivity of the latter is the lesser the more powerful are the flares which accompany them. A graphic example of this is the series of geomagnetic disturbances associated with active regions in the 340 to 360° longitude range, which are related to 2 sudden commencement storms. Active regions which are relatively quiet in the meter range and without flares apparently do not exert a significant effect on the escape of the solar wind, which results from hydrodynamic expansion of the corona. The minima in geomagnetic disturbance, observed following the transit of such active regions across the central meridian in this case, are a result of the approach of relatively slow particles toward the Earth. (BBB)

**20763** MECHANISM OF THE EFFECT OF SOLAR ACTIVITY ON PROCESSES IN THE EARTH'S ATMOSPHERE. Maksimov, I. V. (Leningrad Marine Engineering School). Sov. Antarct. Exped. Inform. Bull., 6: 494-9(Sept. 1968).

The variations of the pressure field of the Earth which are associated with the 11-yr solar cycle are considered. In principle, the 11-yr variation of atmospheric pressure, produced by the Sun, can be represented in both hemispheres by a pressure wave that is not very large, but is characterized by crests, or amplitude maxima, located in the vicinity of the poles of the Earth, and by nodal lines that intersect the Earth near 35°N. An equation made it possible to compute sea-level deformation as a function of the distribution of average anomalies of the force of gravity over the surface of the Earth. Using the anomalies of the force of gravity, known for many regions of the northern hemisphere, it was possible to compute by interpolation the probable values of these anomalies for every 10° square. The gravity anomalies of sea level which were computed completely reproduced the known distribution of average atmospheric pressure values in the northern hemisphere. It was shown that the amplitudes of the 11-yr atmospheric pressure fluctuations, computed on the assumption that the value of the gravitational constant changes by 1: 1,000,000 of its magnitude, are very close to the values obtained from observations. At the same time, the unique explanation of the polar nature of the global pressure wave produced by variations in solar activity was found. The agreement between the computed amplitudes of this wave and, particularly, between its character and observational data suggested the concept of the gravitational or, more correctly, of the deformational mechanism of the effect of varying solar activity on the entire combination of processes produced by the Sun in the Earth's troposphere as a promising hypothesis that deserves to be studied in detail. (BBB)

**20764** SOLAR COSMIC RADIATION AND MAGNETOSPHERIC STUDIES DURING 1967–1968. Masley, A. J.; McDonough, J. W.; Satterblom, P. R. (McDonnell Douglas Astronautics Co., Santa Monica, Calif.). Antarct. J. U. S., 3: 203-4(Sept.-Oct. 1968).

Although approaching the time of predicted maximum in the solar cycle, the June 1967 through June 1968 period was relatively quiet. Of the 12 events registered as greater than 0.3 db at 30 MHz, only 1 event had greater than 2 db absorption. November and December 1967 represent a period of increased activity with 5 events during a 6-week interval, but they were relatively small, ranging from 0.4 to 1.8 db. The June 9, 1968 event was the largest observed since May 23, 1967. The event may have been associated with a Class 2B flare located at S13W05 and beginning before 0831 UT on June 9. A maximum absorption of nearly 6 db was reached at 0900 UT on June 10. A high-latitude magnetospheric study based on the Douglas conjugate stations located at 80° geomagnetic latitude was discussed. The events selected for study were not associated with solar flares, were generally small (on the order of 0.5 db), were usually of short duration (averaging about 1 hr), and occurred at a rate of ~14/month. The diurnal distribution of events at McMurdo between March 1962 and January 1967 for peak absorption thresholds of 0.1 and 0.5 db is shown. It is seen that most of the largest events occurred near local magnetic midnight, which is 0700 UT. For the much larger number of events above 0.1 db, the peak occurs near 1900 UT, which is local magnetic noon. The large events, which occur near midnight, tend to be of short duration, whereas the noon group includes those often lasting longer than 2 hr. (BBB)

**20765** MAGNETIC ACTIVITY AND AURORAS AT VOSTOK STATION DURING THE IQSY. Belousov, B. G.; Lukina, L. V.; Fel'dshtein, Ya. I. Sov. Antarct. Exped. Inform. Bull. (Engl. Transl.), 6: 565-7(Sept. 1968).

The relation between auroras and magnetic disturbances at high latitudes during the solar activity maximum and minimum is discussed. The negative correlation between magnetic activity and zenith auroras, established in years of high solar activity, also remains during the period of the minimum. The frequency of zenith auroras P (in %) at Vostok Station in 1965 is shown for various planetary magnetic activity indexes. Zenith auroras appear most frequently when the magnetic field is quiet. As planetary disturbance increases, the probability of auroras decreases and airglow, which can be observed visually and with an all-sky camera, disappears. The variations in the frequency of auroras at Vostok Station are in antiphase most of the day with the variations of magnetic activity, the index of which is the hourly amplitude of the horizontal component. The diurnal distribution of auroras in the vicinity of the geomagnetic pole suggests that energetic particles, responsible for the auroral emission, penetrate into the polar region mainly on the day side of the Earth. The small number of auroras in the morning and at night attests to the impossibility of injection of corpuscular streams. The penetration of particles on the day side is modulated by an additional mechanism, leading to an increase in magnetic disturbance and to a decrease in auroral frequency at 14 hr UT. Auroras appear more frequently in the polar region when the field is relatively quiet and zenith auroras are accompanied by short-period magnetic field variations of low intensity. These irregular fluctuations are quite characteristic for the daytime hours and appear both in the presence and in the absence of auroras. (BBB)

**20766** INTERPRETATION OF THE WHISTLER-EXCITED EMISSIONS IN THE VICINITY OF THE LOW HYBRID FREQUENCY. Cerisier, Jean-Claude (CNRS, Val-de-Marne, France). Compt. Rend., Ser. A, B, 267: 1373-6(Dec. 16, 1968). (In French).

Some radioelectric emissions, apparently excited by whistlers in the vicinity of the low hybrid frequency, can be interpreted as being the whistlers themselves modified by the effects of the nonguided magnetospheric propagation. This interpretation takes account of the temporal variation of the inferior slit frequency of the spectrum of these emissions. (tr-auth)

**20767** PARAMETRIC STUDY OF VLF MODES BELOW ANISOTROPIC IONOSPHERES. Snyder, Floyd P.; Pappert, Richard A. (Naval Electronics Lab. Center, San Diego, Calif.). Radio Sci., 4: 213-26(Mar. 1969).

Weakly attenuated components of the vlf mode spectrum associated with propagation below highly anisotropic ionospheres are presented as a function of frequency and azimuth. In particular, results for the phase velocity, attenuation, polarization mixing ratio, and excitation factor for vertical dipole excitation are presented in the frequency range of 10 to 30 kHz for midlatitude paths, whereas azimuthal dependencies are presented for a frequency of 19.8 kHz and dip angles of 0 and 60°. The ionospheres

are described by exponential electron-density and collision-frequency profiles, and the primary region of wave–plasma interaction falls in the highly anisotropic region of the ionosphere. It is shown that polarization mixing is much more pronounced for a westerly propagation path than for an easterly path at mid-latitudes, and, as a result, principally TE modes can be expected to influence the mode sum for frequencies at least as low as 20 kHz for propagation to the west. On the other hand, as has been shown previously, contribution to the mode sum by principally TE modes for propagation to the east becomes significant only near 30 kHz. Azimuthal anomalies include drastic polarization changes in going from easterly to westerly paths. For example, in the case of transverse propagation at the magnetic equator, it is shown that modes that are pure TM for propagation to the east may be pure TE for propagation to the west. Tantamount to this is the statement that modes that have dominant excitation for propagation to the east may have vanishing excitation for propagation to the west. Azimuthal dependencies are shown to be very often characterized by rapid variation of the mode constants in the neighborhood of north–south or south–north propagation. These variations manifest themselves in marked differences of the mode sum for azimuthal changes at least as small as 10°. Unfortunately, the azimuthal dependencies of the mode constants do not appear to lend themselves to any simple analytical approximations. (auth)

**20768** EQUATORIAL COUNTER ELECTROJET AND INVERSE Sq CURRENT LAYERS. Gouin, Pierre; Mayaud, Pierre-Noeel (Univ. Haile Selassie, Addis-Abbaba, Ethiopia. Faculte des Sciences, Paris). Compt. Rend., Ser. A, B, 268: 357-60 (Jan. 27, 1969). (In French).

By a comparison of the diurnal variations of the terrestrial magnetic field from a station situated near the magnetic equator and from two stations situated at medium latitudes, it is suggested that the equatorial counter-electrojet belongs to the Sq current layers of which the sense of circulation is inverse to that of the classical layers. (tr-auth)

**20769** COMPARISON BETWEEN FORMULAS FOR IONOSPHERIC RADIO PROPAGATION AND ATMOSPHERIC WAVE PROPAGATION. Davies, Kenneth; Baker, Donald M.; Chang, Norman J. F. (Space Disturbances Lab., Boulder, Colo.). Radio Sci., 4: 231-4(Mar. 1969).

Attention is drawn to similarities between certain magnetoionic formulas in ionospheric radio propagation and corresponding formulas for acoustic-gravity waves. Acoustic waves are similar to radio waves with frequencies above the electron gyrofrequency, whereas gravity waves are similar to whistlers. (auth)

**20770** NOTE ON NEW NUMERICAL MAPS OF $f_0E_s$ FOR SOLAR CYCLE MINIMUM AND MAXIMUM. Leftin, M.; Ostrow, S. M.; Preston, C. (Inst. for Telecommunication Sciences, Boulder, Colo.). Radio Sci., 4: 227-30(Mar. 1969).

Limitations of numerical maps of lower decile, median, and upper decile values of $f_0E_s$ derived for each month of both a solar cycle minimum and a solar cycle maximum year, and some applications to propagation problems are discussed briefly. The numerical map coefficients and contour charts for representative months and hours of the day in 1954 and 1958 are published. (auth)

**20771** MAGNETOSPHERIC SUBSTORM AS A DISCHARGE PROCESS. Akasofu, Syun-ichi (Univ. of Alaska, College). Nature (London), 221: 1020-22(Mar. 15, 1969).

It is shown that the asymmetric electric current system associated with the magnetospheric substorm can be unstable in the sense discussed by Alfvén and Carlqvist, and also that the major features of the magnetospheric substorm can be explained as various consequences of the instability. (W.D.M.)

**20772** DIFFUSION IN A NONISOTHERMAL PLASMA (IONOSPHERE). Tsedilina, E. E. (Inst. of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 621-2(1968).

Translated from Geomagn. Aeron., 8: 780-1(1968).

The tensors of electron and ion diffusion, obtained with allowance for electron–ion collisions in plasma, were presented by Gurevich and Tsedilina (1967). In deriving the components of the diffusion tensors, it was assumed that the plasma is isothermal, i.e., that the electron temperature $T_e$ is equal to the ion temperature $T_i$. But the temperature equilibrium can be disturbed in a plasma. It is known that $T_e$ in the upper ionosphere, where collisions between charged particles are significant, can differ from $T_i$ and the $T_e/T_i$ ratio can be 2 or 3. An attempt is made to obtain more general expressions for the components of the tensors of diffusion and for the coefficient of ambipolar diffusion that would be applicable to a nonisothermal plasma. Computations similar to those performed by Gurevich and Tsedilina give values for the components of electron and ion diffusion for an arbitrary degree of plasma ionization. (W.D.M.)

**20773** MODELING OF THE INTERACTION OF THE SOLAR WIND WITH THE GEOMAGNETIC FIELD. Managadze, G. G.; Podogornyi, I. M. Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 496-9(1968).

Translated from Geomagn. Aeron., 8: 618-23(1968).

The possibility of simulating the interaction of the solar wind with the geomagnetic field is examined. Exact modeling of all the processes in the magnetosphere is practically impossible, but it is possible to select such experimental parameters as to simulate the most interesting cosmic phenomena in the laboratory. The results of experiments on the formation of the neutral sheet are presented as an example of the correctness of limited modeling. (auth)

**20774** PLASMA MOTIONS IN THE F REGION OF THE IONOSPHERE ACCOMPANYING THE MOTIONS OF THE NEUTRAL GAS. Fatkullin, M. N. (Inst. of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 511-17(1968).

Translated from Geomagn. Aeron., 8: 638-45(1968).

Plasma motions generated by movements in the upper atmosphere are examined. The entrainment of the plasma by the diurnal "breathing" of the atmosphere is also discussed. It follows from the estimates that the vertical component of plasma velocity, produced by horizontal movements in the atmosphere, has a marked diurnal pattern at middle and high latitudes. The meridional component of plasma velocity, produced by the meridional wind component, is directed northward during the daytime and southward at night. Motions in the upper atmosphere do not produce significant zonal plasma motions. It is shown that vertical movements of the plasma at velocities of ~100 m/sec have no effect on hydrostatic equilibrium conditions in the upper atmosphere. The plasma does not follow the vertical displacements of the neutral gas at the levels of the F region at low latitudes. (auth)

**20775** DETERMINATION OF IONOSPHERIC PLASMA DENSITY FROM PHASE–FREQUENCY CHARACTERISTICS. Afraimovich, E. L. (Ionospheric Section, Alma-Ata, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 518-22(1968).

Translated from Geomagn. Aeron., 8: 646-51(1968).

The construction of N(h) profiles from phase–frequency characteristics, representing the dependence of the frequency derivative of the phase on operating frequency, is discussed. An installation, designed for the automatic measurement of phase–frequency characteristics by means of a vertical sounding ionospheric station, is described. (auth)

**20776** TRIPLE SPLITTING OF RADIO WAVES IN THE E REGION AT MIDDLE LATITUDES. Gerasimova, G. N.; Gerasimov, G. I.; Korinevskaya, N. A. (Ionospheric Section, Alma-Ata, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 523-6(1968).

Translated from Geomagn. Aeron., 8: 652-6(1968).

Data are presented on the triple splitting of radio waves in the E, E2, and $E_s$ layers at middle latitudes. The frequency of appearance of the z component in the E region during the IQSY period is examined on the basis of data from Karaganda station. The diurnal and seasonal patterns of appearance of the x and z components and their relation to radio-wave absorption at a frequency of 2.2 MHz are analyzed. (auth)

**20777** INVESTIGATION OF THE SMALL-SCALE PORTION OF THE SPECTRUM OF IONOSPHERIC INHOMOGENEITIES BY THE RADIO ASTRONOMIC METHOD AT FREQUENCIES OF 13 TO 54 MHz. Erukhimov, L. M.; Ryzhov, V. A. (Gorky State Univ., USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 527-33(1968).

Translated from Geomagn. Aeron., 8: 657-64(1968).

The statistical characteristics of fluctuations in radio noise from Cassiopeia A at three to six frequencies are investigated. It is shown that, during the observation period, the phase fluctuations of the wave in an inhomogeneous layer were less than 1 radian at frequencies $f \geq 13$ MHz. In some cases, the correlation function for inhomogeneities was other than Gaussian. Estimates of fluctuations in electron concentration in the ionosphere are presented for inhomogeneities measuring ~1 km. (auth)

**20778** INVESTIGATION OF THE HORIZONTAL, VERTICAL, AND TOTAL VECTOR OF DRIFT VELOCITY OF SMALL-SCALE IONIZATION INHOMOGENEITIES IN THE IONOSPHERE. Drobzhev, V. I. (Ionospheric Section, Alma-Ata, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 534-7(1968).

Translated from Geomagn. Aeron., 8: 665-70(1968).

The main results of investigations of the behavior of the horizontal, vertical, and total drift velocity vectors of small-scale

inhomogeneities in the F2 region as a function of the time of day and season are reported. (auth)

**20779** SOME RESULTS OF OBSERVATIONS OF TRAVELING DISTURBANCES IN THE ARKHANGEL'SK AREA. Bukin, G. V.; Grigor'ev, G. I. (Inst. of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Moscow. Gorky State Univ., USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 538-43 (1968).

Translated from Geomagn. Aeron., 8: 671-8 (1968).

The results of observations in 1965–1966 on traveling ionospheric disturbances at a network of spaced stations are reported. The true vertical velocity of the inhomogeneities is determined. The computed delay time in the appearance of disturbances on two branches of an ionogram agrees with the experimentally measured time. (auth)

**20780** PROPERTIES OF THE IONOSPHERE AT LOW FREQUENCIES. Fligel, D. S. (Inst. of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 544-50 (1968).

Translated from Geomagn. Aeron., 8: 679-87 (1968).

The results of computations of the coefficients of refraction and attenuation for heights z = 60 to 6000 km are reported. The parameters of the ionosphere obtained in recent years were used in the computations. The coefficients of transmission and of the average phase velocity of low-frequency waves in the ionosphere are estimated. (auth)

**20781** DISTRIBUTION OF ATOMIC OXYGEN IN THE POLAR MESOSPHERE AT NIGHT. Byutner, E. K.; Dmitrieva, L. K. Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 551-6 (1968).

Translated from Geomagn. Aeron., 8: 688-96 (1968).

It is concluded on the basis of experimental measurements of the intensity and energy of corpuscular streams in auroras that polar-night auroras are equivalent to a constant emission of energy $I_0 \approx 5$ erg/cm$^2$ sec. This source ionizes the atmospheric components in the layer of maximum auroral intensity. Atomic oxygen forms in this layer as a result of secondary chemical reactions and its amount depends on the time of passage of an air mass through the layer where corpuscular streams lose most of their energy. The vertical distribution of oxygen atoms in the layer from 105 to 75 km is computed for the winter and summer. (auth)

**20782** MECHANISM OF THE ACTION OF SOLAR ACTIVITY ON THE CYCLE OF OSCILLATION OF ATMOSPHERIC CIRCULATION. Elekoev, B. B. (Leningrad Hydrometeorological Inst.). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 562-5 (1968).

Translated from Geomagn. Aeron., 8: 703-7 (1968).

The mechanism by which unstable disturbances of a planetary scale are generated in zonal baroclinic flow under the effect of lunar and solar semidiurnal tides is investigated. A mechanism of the effect of solar activity on the duration of the transition from zonal to meridional circulation is proposed. (auth)

**20783** UNSTEADY REGIME OF ATMOSPHERIC OZONE. Steblova, R. S. (Inst. of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 566-8 (1968).

Translated from Geomagn. Aeron., 8: 708-11 (1968).

Short-period variations, attaining 30 to 50% of the stable value, are observed in the ozone content during the daytime. The effect of the disturbances of the steady-state regime is, as a rule, associated with active phenomena on the Sun. The disturbances of the steady-state regime of the ozonosphere, associated with this, are brief, but rather frequent, particularly in years of maximum solar activity. They affect the annual patterns of the total zone content and of the effective temperature. (auth)

**20784** DEVELOPMENT OF A POLAR STORM. Belyakova, S. I.; Zaitseva, S. A.; Pudovkin, M. I. (Leningrad State Univ.). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 569-73 (1968).

Translated from Geomagn. Aeron., 8: 712-18 (1968).

A rapid shift of auroral arcs toward the equator is observed during the initial phase of a polar storm in the auroral zone, i.e., the movement of the source of ionizing radiation in the tail of the magnetosphere toward the Earth. The auroral band widens at the same time. A slight increase in the horizontal component of the geomagnetic field at the equator (10 to 15 $\gamma$), probably associated with an increase in the pressure exerted by a solar corpuscular stream on the geomagnetosphere, is observed approximately 1.5 hours prior to the beginning of a polar storm. (auth)

**20785** SOME PROPERTIES OF Pc1-TYPE PULSATIONS OF THE ELECTROMAGNETIC FIELD OF THE EARTH, OBSERVED SIMULTANEOUSLY OVER A WIDE AREA. Troitskaya, V. A.; Baranskii, L. N.; Vinogradov, P. A.; Sobolev, A. V.; Solov'ev, S. I. (Inst. of Terrestrial Physics, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 579-82 (1968).

Translated from Geomagn. Aeron., 8: 726-30 (1968).

The characteristics of the passage of individual series of Pc1 pulsations at a network of stations are investigated. (auth)

**20786** MEAN ANNUAL CHARACTERISTIC OF THE STATE OF IONIZATION OF THE F2 LAYER. Likhachev, M. A. (Tomsk State Univ., USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 622-4 (1968).

Translated from Geomagn. Aeron., 8: 782-4 (1968).

A statistical analysis of observational data previously showed that the mean annual values of the ionization parameter $\bar{y}$ differ little for various stations. This circumstance served as the reason for investigating the distribution of $\bar{y}$ as a function of latitude in the solar activity cycle. The mean annual value of the characteristic of the state of ionization $\bar{y}$ was computed for individual ionospheric stations of the global network for the period from 1957 through 1965 from the monthly medians of the critical frequencies at noon $f_0F2_{max}$. (W.D.M.)

**20787** RELATIONSHIP BETWEEN THE CONDITIONS OF FORMATION OF THE F1 LAYER AND ION COMPOSITION. Shchepkin, L. A. (Inst. of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Novosibirsk, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 625-6 (1968).

Translated from Geomagn. Aeron., 8: 785 (1968).

It was mentioned previously that the formation of a local maximum on the N(h) profile in the intermediate region of the ionosphere (150 to 200 km), corresponding to the F1 layer, is associated with the equilibration of the absolute values of the height (h) derivatives of the concentrations of atomic $O^+$ and molecular $O_2^+$ and $NO^+$ ions. The reasons for this are the comparable concentrations of ions of the above kinds in this region of the ionosphere and the fact that the F1 layer forms at those heights where the concentration of molecular ions decreases with height. Proceeding from these considerations, the conditions for the formation of the F1 layer are analyzed from the viewpoint of the height dependence of ion concentrations. (W.D.M.)

**20788** MEASUREMENTS OF ELECTRON CONCENTRATION IN THE POLAR IONOSPHERE. Troitskii, B. V. (Inst. of Physics and Tech., Novosibirsk, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 626-9 (1968).

Translated from Geomagn. Aeron., 8: 786-8 (1968).

The interaction of a narrow bundle of transverse waves with a frequency $\Omega^t \gg \omega_0$ and a bandwidth $\Delta\Omega^t \ll \omega_0 = (4\pi e^2 n_0/m_e)^{1/2}$ with longitudinal plasma waves leads to the appearance in the radiation spectrum of the side waves with frequencies $\Omega^t = \Omega_0^t \pm n\omega_0$, n = 1, 2, 3 . . . . Then, by recording the frequency of the first side wave, for example, it is easy to compute the electron concentration value. On the basis of the theory of transmission of hf transverse waves through a turbulent plasma, it is demonstrated that the first side waves can have an intensity that can be detected. (W.D.M.)

**20789** RELATIONSHIP BETWEEN AURORAL ABSORPTION AND GEOMAGNETIC ACTIVITY. Zhukova, T. P. (Inst. of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Novosibirsk, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 632-3 (1968).

Translated from Geomagn. Aeron., 8: 792-4 (1968).

The purpose of this study was to examine the relationship between auroral absorption and auroral disturbance. Use was made of the cosmic noise data obtained at Noril'sk by two riometers at 32 and 40 MHz over the period from Jan.–May and in Sept. 1966. Cosmic noise was received on two five-element Yagi antennas pointing to the celestial pole and having the radio pattern width in the E 50° and H 60° planes. 45 bays characterizing auroral absorption exceeding 0.3 dB and of a duration of more than 30 minutes were selected for analysis. (W.D.M.)

**20790** ESTIMATE OF ELECTRIC FIELDS IN THE MAGNETOSPHERE FROM THE FREQUENCY DRIFT OF MICROPULSATIONS. Troitskaya, V. A.; Shchepetnov, R. V.; Gul'elmi, A. V. (Inst. of Terrestrial Physics, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 634 (1968).

Translated from Geomagn. Aeron., 8: 795 (1968).

A method is proposed for estimating electric fields in the magnetosphere. It is assumed that the frequency of micropulsations varies as a result of the radial drift of emitters toward the interior of the magnetosphere and $\varphi \sim$ const $\Omega_i^\nu$, where $\Omega_i = eH/m_ic$. It is further assumed that the proportionality coefficient and the exponent $\nu$ do not change in the course of drift and the dipole approximation of the geomagnetic field is selected: $H \sim L^{-3}$. In this case, the rate $V_{dr} = dL/dt$ of displacement of the region of generation across L shells will be $V_{dr} \sim (L/3\nu)(d \ln \omega/dt)$. On the other hand, $V_{dr} = c(e_\perp/H)$, so that $E_\perp(v/cm) \sim (0.65/L^2\nu)(d \ln \omega/dt)$. (W.D.M.)

**20791** A PARTICULAR CASE OF GEOMAGNETIC PULSATIONS OBSERVED IN THE EQUATORIAL REGIONS OF AFRICA. Roquet, Juliette (Institut de Physique du Globe, Paris). Compt. Rend., Ser. A, B, 268: 581-4(Feb. 17, 1969). (In French).

A case of Pc1 registered on February 28 and 29, 1968, is examined, which, contrary to that which is usually observed for the Pc1-type pearls, is more pronounced in the equatorial regions than at medium and high latitudes. (tr-auth)

**20792** INDUCED AND COMBINATION RADIO WAVE SCATTERING IN IONOSPHERE AND MAGNETOSPHERE. Trakhtengerts, V. Yu. (Gorky State Univ., USSR). Izv. Vyssh. Ucheb. Zaved., Radiofiz., 11: 1819-28(1968). (In Russian).

The peculiarities of induced and combinational scattering of rf radio waves in the ionosphere and magnetosphere are considered. For the case of combinational scattering by magnetospheric nonequilibrium plasma noises, the cross sections of scattering may exceed considerably a classical cross section of scattering by free electrons. Hereby, a method may appear more effective of investigating a magnetospheric plasma based on the reception of combinational frequencies of scattered radiation biased relative to the original frequency to the plasma frequency and the harmonics of electron gyrofrequencies. The possibilities of detecting plasma turbulence in the ionosphere using satellite radio signals are discussed. (auth)

**20793** TURBULENCE IN A CONDUCTIVE ATMOSPHERE. Khantadze, A. G. (Inst. of Geophysics, Tbilisi, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 746-7(1968).

Translated from Geomagn. Aeron., 8: 933-4(1968).

A theory of turbulence in the free atmosphere was developed by Laikhtman and Byntner (1962) and Laikhtman and Shnaydman (1960). This theory is generalized for the ionosphere, which differs from the free atmosphere mainly by its conductivity. (W.D.M.)

**20794** VARIATIONS IN THE IONIZATION RATE IN A QUIET F2 LAYER IN THE SOUTH POLAR CAP. Kolomiitsev, O. P. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 748-50(1968).

Translated from Geomagn. Aeron., 8: 935-7(1968).

To study the ionization sources of the high-latitude ionosphere and their variations as a function of season, latitude, and the solar activity cycle, the ionization rates q(h) in the F2 layer were computed from vertical ionospheric soundings at Antarctic stations in the polar cap. Data from the Amundsen–Scott, Vostok, and Byrd stations were selected for analysis. (W.D.M.)

**20795** INFLUENCE OF THE 11-YEAR SOLAR-ACTIVITY CYCLE ON THE CRITICAL FREQUENCY OF THE IONOSPHERIC F2 REGION. Khocholava, G. M. (Inst. of Geophysics, Tbilisi, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 750-1(1968).

Translated from Geomagn. Aeron., 8: 938-9(1968).

The influence of the 11-year solar-activity cycle on the critical frequency of the ionospheric F2 layer has been previously investigated on the basis of observational data prior to the beginning of the IGY. This paper is devoted to the study of the day-to-day variability of critical F2-layer frequencies at 12 and 0 h LT. Use is made of monthly $f_0F2$ tables for Moscow over the latest solar-activity cycle. (W.D.M.)

**20796** PREDAWN EFFECT IN $f_0$ F2 VARIATIONS CAUSED BY SUNRISE AT A MAGNETICALLY-CONJUGATE POINT. Bukin, G. V.; Evzovich, N. P.; Katsenel'son, I. B.; Sukhorukova, E. V.; Elizar'ev, Yu. N.; Shatkhin, Kh. Z. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Moscow. Rostov-on-Don State Univ., USSR. Siberian Physical-Technical Inst., Tomsk, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 752-4(1968).

Translated from Geomagn. Aeron., 8: 940-2(1968).

Computations show that for Soviet stations, located at geomagnetic latitudes from 30 to 65°, the length of the line of force connecting the magnetically conjugate points is 10,000 to 80,000 km. The time within which photoelectrons with energies 10 to 30 eV are transported along this line is several minutes. At the same time, the difference between sunrise at the observation point and at the conjugate point is more than 1 hour in winter for low-latitude stations and increases with latitude. Thus, one can expect an increase in $f_0F2$ in the predawn hours, as a result of the transfer of photoelectrons from the illuminated conjugate region, using the results of standard 15-minute observations. (W.D.M.)

**20797** VARIATIONS IN THE THICKNESS OF THE INTERMEDIATE E–F REGION. Freizon, A. A.; Shapiro, B. S. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 754-6(1968).

Translated from Geomagn. Aeron., 8: 943-4(1968).

The results of approximate computations of the variations in the thickness of the intermediate E–F region in the daytime during the IGY and IQSY are reported. Use was made of the data a N(h) based on observations at the middle-latitude station Moscow. An analysis of the computed data by rigorous methods shows that the form of the daytime N(h) at middle latitudes is similar to that of the Chapman layer. (W.D.M.)

**20798** RATE OF VARIATION OF ELECTRON CONCENTRATION IN THE E REGION AT LARGE $Z_\odot$. Korsunova, L. P.; Ivanov-Kholodynyi, G. S. (Inst. of Applied Geophysics, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 757-8(1968).

Translated from Geomagn. Aeron., 8: 945-6(1968).

The results of vertical soundings of the E region at $Z_\odot$ = 70 to 90° at Moscow, Sverdlovsk, Towsk, and Irkutsk were examined. The results of 15-min measurements on all the magnetically quiet days ($K \leq 3$) of each month from May 1963 through May 1964 were selected for analysis. Critical frequencies $f_0E$, averaged for each $Z_\odot$, were used to determine $N_e$ at the layer maximum for the morning and evening separately. The dependence of $N_e$ on the Chapman function Ch $Z_\odot$ was plotted for each month. (W.D.M.)

**20799** DURATION OF CONTINUOUS REFLECTIONS FROM $E_s$. Solchatova, L. Ya. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Novosibirsk, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 759-60(1968).

Translated from Geomagn. Aeron., 8: 947(1968).

The relationship of form $T = T_0 X \exp k (f_0E_s)_{max}$ proposed previously was verified on the basis of data from Irkutsk for the half-cycle of solar activity from 1959 to 1964. (W.D.M.)

**20800** VARIATIONS IN THE LIMITING FREQUENCIES OF THE $E_s$ LAYER. Starovatov, A. A. (Ionospheric Section, Alma-Ata, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 760-1(1968).

Translated from Geomagn. Aeron., 8: 948-9(1968).

The $f_0E_s$ data obtained at Alma-Ata from 1943 to 1965 were analyzed. No relationship was found between the limiting frequencies and the solar activity cycle. The seasonal $f_0E_s$ pattern was determined by the 6- and 12-month components and the diurnal 8-, 12-, and 24-hour components. Some characteristics in the behavior of $E_s$ were compared with the detected periodicity of limiting frequencies. (W.D.M.)

**20801** ION COMPOSITION OF THE NIGHTTIME IONOSPHERE. Zhlud'ko, A. D. (Inst. of Experimental Meteorology, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 762-5(1968).

Translated from Geomagn. Aeron., 8: 950-3(1968).

A nighttime experiment was performed at 1h 15m LT on May 30, 1967, several hours after a relatively intense magnetic storm, at middle latitudes in the European USSR to study the composition of positive ions in the E layer. (W.D.M.)

**20802** COMPUTATIONS OF IONOSPHERIC N(h) PROFILES WITH ALLOWANCE FOR INTERLAYER AND UNDERLYING IONIZATION. Vinnikova, T. L.; Freizon, A. A.; Shapiro, B. S. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 765-7(1968).

Translated from Geomagn. Aeron., 8: 954-6(1968).

Programs for computing N(h) from a single component (ordinary or extraordinary) and the corresponding coefficients were developed previously. An algorithm for computing N(h) with the combined use of both magnetoionic components is described. This algorithm was developed on the basis of the aforementioned programs. This kind of analysis makes it possible to account for interlayer and underlying ionization. (W.D.M.)

**20803** SOME CHARACTERISTICS OF ANOMALOUS RADIO WAVE ABSORPTION IN THE IONOSPHERE IN THE AURORAL ZONE. Benediktov, E. A.; Tolmacheva, A. V. (Gorky State Univ., USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 768-9(1968).

Translated from Geomagn. Aeron., 8: 957-8(1968).

Auroral radio-wave absorption in the ionosphere is usually measured by the radio astronomical method at 25 to 40 MHz. Main emphasis is placed on the study of disturbances with an integral radio-wave absorption $\Gamma \gtrsim 0.5$ dB (this limitation is imposed by absorption measurement errors amounting to 0.1 to 0.2 dB). At the same time, study of weaker disturbances presents some interest. Some results of investigations of this kind at low operating frequencies are reported. (W.D.M.)

**20804** INFLUENCE OF VERTICAL MOVEMENTS OF THE LOWER IONOSPHERE AT NIGHT ON SLOW CHANGES IN THE

TOTAL FIELD STRENGTH OF RADIO WAVES. Yampol'skii, V. S. (Omsk Pedagogical Inst., USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 770-1(1968).

Translated from Geomagn. Aeron., 8: 959-60(1968).

To determine which processes have the strongest effect on the change in total field strength at the reception point, a spectral analysis was performed of E records for the night hours from January to October 1963 (the length of the link was 930 km, the transmitter frequency was 385 kHz, and the latitude of the midpoint of the link was about 50°. The data were divided into hourly intervals and the quasi-periodic variations of E were determined by the method of integral Fourier transformations. (W.D.M.)

**20805** POSSIBLE NATURE OF THE FINE STRUCTURE OF AURORAS. Trakhtengerts, V. Yu. (Gorky State Univ., USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 776-9(1968).

Translated from Geomagn. Aeron., 8: 966-8(1968).

Energetic particles, especially electrons, are frequently dumped in the auroral zone in individual bursts. The properties of these bursts (or microbursts) have been described in detail. The frequency of the bursts is usually $f_b \sim 1$ burst/sec and they are generally superposed on the enhanced background of fluxes of precipitating particles. The microbursts are found to be very localized in space. The fine structure of auroras, i.e., the appearance of very narrow, bright, and moving rays, rapid auroral intensity pulsations, etc., is probably associated with this characteristic of particle precipitation. An attempt is made to explain the foregoing phenomena by means of some characteristic properties of plasma instabilities. (W.D.M.)

**20806** SOME GEOPHYSICAL PHENOMENA OBSERVED AT NORIL'SK DURING AURORAL DISPLAYS. Zherebtsov, G. A.; Zainagabdinova, R. F.; Kurilov, V. A. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Novosibirsk, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 779-80(1968).

Translated from Geomagn. Aeron., 8: 969(1968).

The brightness I and position of auroras in the sky are compared with the relative sunspot numbers, the sunspot area, and the magnetic indexes $C_p$ and $\Sigma k$ in the course of a day at Noril'sk. Comparisons were made with auroras in the northern sector of the sky. The observation period (Oct. 1965 to April 1966) was characterized by low solar activity and, therefore, sharp variations in solar activity stood out clearly against the general background. (W.D.M.)

**20807** RELATIONSHIP BETWEEN 11-YEAR CYCLIC VARIATIONS IN PULSATIONS OF THE PEARL TYPE (Pc1) AND SOLAR ACTIVITY. Matveeva, E. T.; Gnevyshev, M. N.; Troitskaya, V. A. (Inst. of Terrestrial Physics, Moscow. Borok Main Astronomical Observatory, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 783-4(1968).

Translated from Geomagn. Aeron., 8: 973-4(1968).

The first homogeneous series of Pc1 observations has been obtained for a complete solar activity cycle. The patterns of Pc1 excitation in the cycle were found to be very unusual and unexpected: the maximum number of excitations coincided with years intermediate between the solar activity maximum and minimum. (W.D.M.)

**20808** CHANGE IN THE FREQUENCY OF Pc1 MICROPULSATIONS DURING A SUDDEN DEFORMATION OF THE MAGNETOSPHERE. Troitskaya, V. A.; Matveeva, E. T.; Ivanov, K. G.; Gul'elmi, A. V. (Inst. of Terrestrial Physics, Moscow. Borok Geophysical Observatory, USSR. Inst. of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 784-6(1968).

Translated from Geomagn. Aeron., 8: 975-6(1968).

The purpose of the present study was to try to apply the method of Gul'el'mi (1967) to the analysis of specific changes in the frequency of Pc1 during sudden impulses and sudden commencements. Micropulsation records from Borok, Lovozero, Petropavlovsk, Alma-Ata, Mirny, and Piramida and data on the magnitude of sudden impulses at the equatorial stations Guam, Bangui, Paramaribo, and Memambetsu were used as initial data. (W.D.M.)

**20809** ANALYTICAL MODEL OF THE GEOMAGNETIC FIELD ACCORDING TO COSMOS 49 DATA. Tyurmina, L. O. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 786-8(1968).

Translated from Geomagn. Aeron., 8: 977-8(1968).

An analytical model of the geomagnetic field was computed by spherical analysis from the results of measurements of the total vector of the geomagnetic field on Cosmos 49. The model obtained may contribute to the particular model of the International Analytical Field, proposed by the USSR. (W.D.M.)

**20810** STRUCTURE OF THE GEOMAGNETIC FIELD AT GREAT DISTANCES FROM THE EARTH. Antonova, A. E.; Shabanskii, V. P. (Moscow State Univ.). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 639-47(1968).

Translated from Geomagn. Aeron., 8: 801-11(1968).

The shape of the magnetosphere boundary was determined and the magnetic lines of force were computed for various parameters characterizing the solar wind and the current layer in the framework of the model of the two-dipole approximation with allowance for the current layer in the tail of the magnetosphere. The distant regions of the magnetosphere on the day side were determined. The field intensity along the lines of force in these regions can have two and three minima in contrast to a single minimum for the lines of force of internal regions. The projections of these regions onto the equatorial plane and the Earth's surface were plotted. (auth)

**20811** IONS AT HEIGHTS OF 1000 TO 1200 km, ACCORDING TO COSMOS 5 MEASUREMENTS. Dzhordzhio, N. V.; Fedorova, N. I. (Inst. of Atmospheric Physics, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 648-51(1968).

Translated from Geomagn. Aeron., 8: 812-16(1968).

A method of measuring the concentration of light ions with a trap is described. The concentration and temperature of $O^+$ and $He^+$ ions, measured on four passes of the satellite, are given. The combined concentration of $O^+ + H^+$ ions at night at heights of 1000 to 1200 km at middle latitudes is 1% of the total ion concentration. The nighttime ion temperature at these heights is ~500 to 600°K. The concentration of $He^+$ is found to increase in the vicinity of the geomagnetic equator. (auth)

**20812** DETERMINATION OF THE TOTAL NUMBER OF ELECTRONS IN THE IONOSPHERE FROM THE FARADAY EFFECTS BY MEANS OF SIGNALS FROM THE ATS-3 SATELLITE. Felske, D.; Bardey, H. (Heinrich Hertz Inst. of Solar-Terrestrial Physics, Berlin. Ionospheric Observatory, Kuehlungsborn, Ger.). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 667-70(1968).

Translated from Geomagn. Aeron., 8: 835-9(1968).

The angle of rotation of the polarization plane of the radio signal from the ATS-3 satellite was measured. (auth)

**20813** RELATIONSHIP BETWEEN THE NORTH–SOUTH SYMMETRY OF THE CRITICAL FREQUENCIES OF THE F2 REGION OF THE IONOSPHERE AND THE ANGLE OF INCLINATION OF THE GEOMAGNETIC AXIS. Lopatina, G. B. (Moscow State Univ.). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 677-81(1968).

Translated from Geomagn. Aeron., 8: 847-52(1968).

Two profiles along the parameter L of the median $f_0F2$ values of ionospheric stations along geomagnetic longitudes 350 and 210° at middle latitudes at night were analyzed for a year of minimum solar activity. The asymmetry observed between the northern and southern hemispheres was compared with the change in the angle of deviation of the geomagnetic axis from the normal to the plane of the ecliptic. A direct relationship was obtained between these quantities. It is shown that the north–south asymmetry increases with increasing solar activity. (auth)

**20814** ADDITIONAL STRATIFICATION IN THE F REGION ACCORDING TO OBSERVATIONS AT ALMA-ATA. Korinevskaya, N. A. (Ionospheric Section, Alma-Ata, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 682-4(1968).

Translated from Geomagn. Aeron., 8: 853-7(1968).

Data on additional stratifications in the F region are presented. It is shown that F1.5 is a regular layer that appears as an intermediate formation when traveling disturbances cross the ionosphere. The G layer is the initial form of a sequence of traveling disturbances. (auth)

**20815** CORPUSCULAR HEATING OF THE POLAR IONOSPHERE. Nagorskii, P. M.; Troitskii, B. V. (Siberian Physical-Technical Inst., Tomsk, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 685-8(1968).

Translated from Geomagn. Aeron., 8: 858-62(1968).

The energy of precipitating electrons is examined as a possible source of the heating of the polar ionosphere. The transfer of energy is achieved by means of plasma waves generated as the beam travels through the ionosphere. Estimates show that the heating of the F2 layer of the ionosphere can be quite substantial during strong geomagnetic disturbances. (auth)

**20816** RADIO-ASTRONOMICAL INVESTIGATION OF IONOSPHERIC INHOMOGENEITIES BY THE SPACED-RECEIVER METHOD. Kokurin, Yu. L.; Ovsyankin, M. A. (Lebedev Inst. of Physics, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 689-92(1968).

Translated from Geomagn. Aeron., 8: 863-7(1968).

The characteristics of the spaced receiver method in its application to the radio astronomical investigation of large iono-

spheric inhomogeneities are examined. The preliminary results of measurements by this method of the spectrum of the linear dimensions and velocities of large ionospheric inhomogeneities are reported. It is shown that these parameters are associated with the dynamics of sunspots. (auth)

**20817** STRUCTURE OF THE MAGNETIC FIELD IN THE MAGNETOSPHERE DURING THE RECOVERY PHASE OF A MAGNETIC STORM. Molchanov, O. A. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 693-7(1968).

Translated from Geomagn. Aeron., 8: 868-73(1968).

A method of computing the structure of the geomagnetic field with allowance for external sources is described. The results of computations of the field during the recovery phase of a magnetic storm, performed under certain assumptions regarding the parameters of the disturbing currents, are presented. (auth)

**20818** RESULTS OF OBSERVATIONS ON SUDDEN FLARE-UPS OF COSMIC NOISE ABSORPTION IN THE IONOSPHERE. Benediktov, E. A. (Gorky State Univ., USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 698-701(1968).

Translated from Geomagn. Aeron., 8: 874-8(1968).

The statistical results of observations on sudden flare-ups of radio-wave absorption in the ionosphere, based on measurements of the cosmic-noise intensity level in the decameter wave range, are reported. Estimates of ionospheric parameters at the level of the layer of anomalous ionization are given for several cases. (auth)

**20819** SOME PROBLEMS IN THE INVESTIGATION OF THE IONOSPHERE BY THE PHASE METHOD. Afraimovich, E. L. (Ionospheric Section, Alma-Ata, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 702-7(1968).

Translated from Geomagn. Aeron., 8: 879-85(1968).

Some methodological problems arising in the investigation of the ionosphere by the phase method are discussed, including the extrapolation of the phase–frequency characteristic in the low-frequency range, and the determination of the absolute value and of the time dependence of the steepness of the true height–frequency characteristic at a fixed frequency. In spite of the fact that the foregoing problems are analyzed without allowance for the geomagnetic field, the main results obtained are also of some importance in a general case. (auth)

**20820** CHANGE IN WHISTLER CHARACTERISTICS IN THE DISTURBED MAGNETIC FIELD OF THE MAGNETOSPHERE. Likhter, Ya. I.; Molchanov, O. A. (Inst. of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Moscow). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 719-23(1968).

Translated from Geomagn. Aeron., 8: 899-904(1968).

The first results of investigations on the influence of a disturbance of the magnetic field on whistler characteristics are reported. It is noted that allowance for these effects for high-latitude whistlers significantly changes the interpretation of experimental data. (auth)

**20821** POLAR STORMS AND THE DEVELOPMENT OF DR CURRENTS. Zaitseva, S. A.; Pudovkin, M. I.; Shumilov, O. I. (Leningrad State Univ. Polar Geophysical Inst., Kola, USSR). Geomagn. Aeron. (USSR) (Engl. Transl.), 8: 724-7(1968).

Translated from Geomagn. Aeron., 8: 905-10(1968).

The relationship between the intensity of polar disturbances and the magnitude of the DR variation of the geomagnetic field is examined. It is shown that at the time of the extremes of the DR field its intensity is proportional to the sum of the energy of particles injected into the upper atmosphere of the Earth. It is assumed that the same mechanism is responsible for the acceleration of auroral particles and the filling of the belt of DR currents. (auth)

## Low-Temperature Physics

*Refer also to abstract 21031.*

**20822** (N-68-37283) ADVANCED SUPERCONDUCTING MAGNETS INVESTIGATION. Stekly, Z. J. J.; Thome, R.; Lucas, E.; Strauss, B. P.; DiSalvo, F. (Avco-Everett Research Lab., Everett, Mass.). Apr. 1968. Contract NAS-8-21037. 169p. (NASA-CR-98030). CFSTI.

The behavior of a composite superconductor, consisting of the superconductor itself and a highly conducting substrate in which all gradients along the conductor are neglected, is analyzed. The simplest case considered is that of a conductor exposed to a coolant assumed to have a constant heat transfer coefficient. The effect of the transition from nucleate to film boiling is investigated and a general steady-state stability map is developed. Following the zero-dimensional analyses, a one-dimensional model in which gradients along the conductor are taken into account was analyzed. Both analyses assume heat transfer to a coolant that can convect heat away. In either of these cases it is not possible to conduct heat to a heat sink very far away without large temperature gradients. The case of three-dimensional heat transfer was investigated, and the special case of only conduction cooling was solved. The predictions of the analytical models were verified experimentally. Specific tests were run on single wires heated locally to verify the results obtained in one-dimensional analysis. Another series of test involved the behavior of a 6''-diameter coil wound with square copper-stabilized Nb–Ti conductor. (auth) (STAR)

**20823** (UCRL-18755) SOME AC LOSS DETERMINATIONS BY AN ELECTRICAL MULTIPLIER METHOD. Gilbert, W. S. (California Univ., Berkeley. Lawrence Radiation Lab.). July 1968. Contract W-7405-eng-48. 5p. (CONF-680621-16). Dep. CFSTI.

From Conference on Superconducting Devices and Accelerators, Upton, N. Y.

The cyclic losses in a superconducting magnet were measured with the electrical multiplier method employing Hall effect multipliers. The magnet was a solenoid 4.5 in. long with a 1.5-in. bore and a 4.5-in. OD wound with a single-core NbTi Supercon wire. The wire core size was 15 mils and conductor was 30 mils overall, giving a copper-to-super conductor ratio of 3:1. It was found that: current density in NbTi systems, above 50,000 A/cm$^2$, are readily achievable if the fraction of stabilizing material can be reduced; losses small enough to make pulsed accelerators attractive have not yet been demonstrated; and a multicore conductor with large (15 mil) cores is degraded when wound into magnets because of flux jumps. (F.S.)

**20824** MICROWAVE CONDUCTIVITY OF GRANULAR ALUMINUM FILMS IN THE SUPERCONDUCTING TRANSITION REGION. D'Aiello, R. V. (RCA Labs., Princeton, N. J.); Freedman, S. J. Phys. Rev. Lett., 22: 515-17(Mar. 17, 1969).

Data are presented on the resistivity of granular aluminum films near the superconducting transition temperature $T_c$ for both dc and 20-GHz excitation. Comparison with a recent theory of the effect of fluctuations on the frequency-dependent resistivity above $T_c$ shows much less excess conductivity than predicted. A possible explanation for the discrepancy may lie in the incorrectness of a currently suggested form for the time-dependent Ginsburg–Landau equation. (auth)

**20825** PHONON SPECTRUM OF SUPERCONDUCTING AMORPHOUS BISMUTH AND GALLIUM BY ELECTRON TUNNELING. Chen, T. T.; Chen, J. T.; Leslie, J. D.; Smith, H. J. T. (Univ. of Waterloo, Ont.). Phys. Rev. Lett., 22: 526-30(Mar. 17, 1969).

The phonon spectra for amorphous Bi and Ga are derived by using McMillan's inversion program on the author's tunneling data. The results indicate an extreme "softening of the phonon spectrum" from what is found for crystalline superconductors. Parameters derived from our phonon spectra are used to test recent theories of the transition temperature of amorphous and strong-coupling superconductors, and also to test the McMillan equation for the maximum possible transition temperature in the limit of extremely strong coupling. (auth)

**20826** MAGNETOSTRICTION DUE TO SURFACE CURRENTS IN TYPE-II SUPERCONDUCTORS. Braendli, G.; Griessen, R. (Eidgenoessische Technische Hochschule, Zurich). Phys. Rev. Lett., 22: 534-7(Mar. 17, 1969).

The mixed state behavior of type-II superconductors is determined by both the flux-line density and the superconductive surface currents. These currents give rise to a new magnetostrictive term that depends on the surface currents and the flux-line density. The new term is found to be very large in the indium alloys investigated. The experimental results are explained theoretically and it is shown that the elastic constants can be calculated from measurements of the new magnetostrictive term. (auth)

**20827** ELECTROMAGNETIC WAVE PROPAGATION IN SUPERCONDUCTORS. Bura, P. (RCA Labs., Princeton, N. J.). RCA Rev., 29: 386-400(Sept, 1968).

Propagation of electromagnetic waves in superconductors differs from propagation in normal metals by the presence of the Meissner effect, i.e., the expulsion of magnetic flux from the superconducting bulk. This is similar to the skin-depth phenomenon of normal metals at microwave frequencies, except that the magnetic-field penetration depth in superconductors is several orders of magnitude smaller than the skin depth and is frequently independent, i.e., the field expulsion takes place in both steady and time-varying fields. Ginzburg and Landau

have proposed a theory to account for the Meissner effect. It is shown that, to the extent that charge effects can be neglected, the equilibrium Ginzburg–Landau equations can be used together with Maxwell's equations to derive the solution to electromagnetic wave propagation in superconductors. The transmission line structures that have negligible fields along the boundary with open space and have transverse dimensions of the order of penetration depth exhibit appreciable variation of the propagation constant with magnetic field (or current). This makes them suitable for distributed traveling-wave parametric amplifiers. (BBB)

**20828** IDEALIZED MODEL OF A SUPERCURRENT. Beck, G. Nuovo Cim., 60B: 8-20(Mar. 11, 1969).

It is shown that there exists a simple model which reproduces qualitatively the main characteristic features of a current flowing through a superconducting material. The model refers to a case of strong coupling which is not yet accessible to a full quantum-electrodynamical treatment, and it still ignores features depending on the intrinsic fluctuations of quantum fields. (auth)

**20829** CONSIDERATIONS ON SUPERCONDUCTORS CONTAINING NONMAGNETIC TRANSITION-METAL IMPURITIES. D'Agliano, E. Galleani (Univ., Genoa); Ratto, C. F. Nuovo Cim., 60B: 121-40(Mar. 11, 1969).

The effect of nonmagnetic transitional impurities on the superconducting critical temperature of nontransition metals is studied. With a slightly modified BCS method a result is found which is shown to be valid more generally. The critical temperature is given by an equation which separates the effect of the impurities on the electron states paired together from that due to the change in the interaction between the two mates of a pair. Our formulas are then compared with experimental results for the Al-base alloys, which seem to confirm the contribution of the localized spin fluctuations in AlMn. (auth)

**20830** IMPROVEMENTS IN AND RELATING TO A SUPERCONDUCTIVE COIL. Lecomte, Jacques; Weil, Louis (to Commissariat a l'Energie Atomique). British Patent 1,146,784. Mar. 26, 1969. Priority date May 25, 1966, France.

The superconducting coil described has an axial former, a transverse disk in its center portion with a radial slot extending from the disk periphery to the axial former, and a superconducting wire coiled on to the former to each side of the disk in contiguous layers. Each layer on one side of the disk being connected in series relationship to the layers on the other side of the disk by portions of the wire which traverse the radial slot. The transverse disk therefore divides the coil into two similar portions. Each portion may contain a plurality of separate windings each intimately connected to a winding on the other side of the disc. Alternatively, each portion may include groups of layers of windings connected in series, each group being connected in series with a group of the other portion. The transverse disk may have, in its thickness, a radial duct permitting observation of articles situated at the center of symmetry of the superconducting coil. The various portions of the coil are made from electrically insulating materials or are covered with such materials. (M.H.R.)

**20831** SUPERCONDUCTOR RIBBON. Britton, R. B.; Robins, K. E.; Sampson, W. B. (to United States Atomic Energy Commission). U. S. Patent 3,432,783. Mar. 11, 1969.

This patent relates to stabilized, superconductor ribbon having a stainless steel substrate, tapered edges, and an insulated aluminum coat whereby the ribbon can be wound into a magnet with cooling channels at the edges of the ribbon and produce strong magnetic fields while reducing the adverse effects of flux jumps in the magnet. (AEC)

**20832** CHARACTERISTICS OF A SUPERCONDUCTING COAXIAL DELAY LINE. Glebovich, G. V.; Gur'eva, I. S. Izv. Vyssh. Ucheb. Zaved., Radioelektron., 10: 1183-8(Dec. 1967). (In Russian).

The frequency and transient responses of a superconducting delay line made of niobium and lead are studied. Results of an experimental investigation are cited. (tr-auth)

**20833** COALESCENCE IN AN ENCLOSED SUPERCONDUCTOR. Gayley, R. I. (State Univ. of New York, Buffalo). J. Phys. Chem. Solids, 30: 459-62(Feb. 1969).

An impure indium rod, enclosed in a tin shell, was cooled in the presence of a constant axial magnetic field. It was observed that superconducting regions in the indium rod coalesced before the transition was complete. This coalescence led to the formation of a closed superconducting surface which inhibited flux expulsion from the rod. (UK)

**20834** VORTRAEGE UEBER SUPRALEITUNG. Physikalische Gesellschaft Zurich, 20 und 27 Mai 1967. (Lectures on Superconductivity. Physical Society of Zurich, May 20–27, 1967). Lehr- und Handbuecher der Ingenieurwissenschaften, Band 27. Basel, Birkhaeuser Verlag, 1968. 208p. Swiss F 26.--. (In German and English). (CONF-670553).

The 11 lectures on superconductivity presented to the Physical Society of Zurich are compiled. Individual abstracts were prepared for each of these papers. (J.S.R.)

*For abstracts of individual chapters see: 20834–20845.*

**20835** HISTORY OF SUPERCONDUCTIVITY. Mendelssohn, K. (Oxford Univ.). pp 9-33 of Vortraege ueber Supraleitung. Basel, Birkhaeuser Verlag, 1968. (In German).

From Lectures on Superconductivity, Zurich, Switzerland. See CONF-670553.

A brief history is given of the experimental and theoretical studies on superconductivity, beginning with the first observation by Onnes in 1911 on mercury. (J.S.R.)

**20836** FUNDAMENTAL FACTS AND PHENOMENOLOGY. Buckel, W. (Technische Hochschule, Karlsruhe, Ger.). pp 35-47 of Vortraege ueber Supraleitung. Basel, Birkhaeuser Verlag, 1968. (In German).

From Lectures on Superconductivity, Zurich, Switzerland. See CONF-670553.

The occurrence of superconductivity in metals is described in order to determine if there is a simple regularity to be found. The disappearance of the electrical resistance and the quantification of the magnetic flux by a superconductor are described. The displacement of the magnetic field (the Meissner–Ochsenfeld effect) is then discussed. The stability of the superconducting phase is considered. The behavior of the specific heat of normal and superconducting phases is discussed. The interaction of electrons with the lattice vibrations is considered as the origin for the occurrence of superconductivity. (J.S.R.)

**20837** THEORY OF SUPERCONDUCTIVITY. Koppe, H. (Univ., Kiel). pp 49-56 of Vortraege ueber Supraleitung. Basel, Birkhaeuser Verlag, 1968. (In German).

From Lectures on Superconductivity, Zurich, Switzerland. See CONF-670553.

A quantum theory of superconductivity is developed, beginning with a review of the theory of metal conductivity. (J.S.R.)

**20838** ELECTRON–ELECTRON INTERACTIONS IN SUPERCONDUCTORS. Peter, M. (Univ., Geneva). pp 57-67 of Vortraege ueber Supraleitung. Basel, Birkhaeuser Verlag, 1968. (In German).

From Lectures on Superconductivity, Zurich, Switzerland. See CONF-670553.

The physical representations concerning the interaction between conducting electrons is developed in a heuristic manner. The relation between this interaction and superconductivity is sketched. (tr-auth)

**20839** SOME RESULTS OF PAIR FORMATION IN SUPERCONDUCTORS. Klein, R. (Labs. RCA Ltd., Zurich). pp 69-93 of Vortraege ueber Supraleitung. Basel, Birkhaeuser Verlag, 1968. (In German).

From Lectures on Superconductivity, Zurich, Switzerland. See CONF-670553.

The basic representations of superconductivity, as developed by Bardeen, Cooper and Schrieffer from the concept of pair correlations, can describe a very large number of experiments. Some expansion of the original theory is necessary, especially the clear separation of the concepts energy holes and pair potential. The hole in the excitation spectrum is not of fundamental significance, but the electron–electron correlation altered with respect to the normal state is, which is shown in an altered-state density. In this manner, the physical properties of the superconductor, which depend on the electron correlations, can be modified. (tr-auth)

**20840** SUPERCONDUCTING MATERIALS. Mueller, J. (Univ., Geneva). pp 95-116 of Vortraege ueber Supraleitung. Basel, Birkhaeuser Verlag, 1968. (In German).

From Lectures on Superconductivity, Zurich, Switzerland. See CONF-670553.

Experimental studies to determine a relation between superconductivity and the basic structure properties of metals and alloys are reviewed. The superconducting elements are tabulated and the critical temperatures of alloying phases are considered. Relations between superconductivity and electron structure or crystal structure are discussed. Dilute alloys and superconducting semiconductors are also considered. (J.S.R.)

**20841** EXPERIMENTAL ASPECTS OF TYPE-II SUPERCONDUCTORS. Olsen, J. L.; Fischer, E. (Eidgenoessische Technische Hochschule, Zurich). pp 117-34 of Vortraege ueber Supraleitung. Basel, Birkhaeuser Verlag, 1968. (In German).

From Lectures on Superconductivity, Zurich, Switzerland. See CONF-670553.

The differences between type-I and type-II superconductivity are briefly summarized. The coherence length and surface energy of type-II superconductors are defined. The structure of the mixed state is given. The behavior of type-II superconductors in the presence of a conductor is described. Surface superconductivity and the upper limit for $H_{c2}$ are discussed. (J.S.R.)

**20842** THEORY OF TYPE-II SUPERCONDUCTIVITY: GINZBURG–LANDAU–ABRIKOSOV–GORKOV THEORY. Klose, W. (Siemens AG, Erlangen, Ger.). pp 135-59 of Vortraege ueber Supraleitung. Basel, Birkhaeuser Verlag, 1968. (In German).

From Lectures on Superconductivity, Zurich, Switzerland. See CONF-670553.

The basic equations of the Ginzburg–Landau–Abrikosov–Gorkov (GLAG) theory are derived from thermodynamics and from the microscopic theory. The mixed state in type-II superconductors is described according to the GL theory. The surface effect is considered. The GL theory is generalized to lower temperatures, to high magnetic fields, and to time-dependent processes. (J.S.R.)

**20843** SUPERCONDUCTING MAGNETS: MATERIALS AND TECHNOLOGY. Montgomery, D. B. (Univ., Lausanne, Switzerland, Massachusetts Inst. of Tech., Cambridge). pp 161-76 of Vortraege ueber Supraleitung. Basel, Birkhaeuser Verlag, 1968.

From Lectures on Superconductivity, Zurich, Switzerland. See CONF-670553.

Some of the basic properties of the superconductors, which make superconducting magnets possible, are described. The construction, economics, and future of superconducting magnets are discussed. (M.H.R.)

**20844** SUPERCONDUCTIVITY IN COMMUNICATIONS ENGINEERING. Dietrich, I. (Siemens AG, Munich). pp 177-90 of Vortraege ueber Supraleitung. Basel, Birkhaeuser Verlag, 1968. (In German).

From Lectures on Superconductivity, Zurich, Switzerland. See CONF-670553.

Superconducting devices and constituents which are already used in communication engineering, although still objects of research, are described. The use of superconducting magnets in communications engineering is first considered. Superconducting thin-layer constituents are then described. These include the cryotron, superconducting accumulator, and tunnel elements. (J.S.R.)

**20845** SUPERCONDUCTING CAVITIES. Citron, A.; Passow, C. (Technische Hochschule, Karlsruhe, Ger.). pp 191-204 of Vortraege ueber Supraleitung. Basel, Birkhaeuser Verlag, 1968. (In German).

From Lectures on Superconductivity, Zurich, Switzerland. See CONF-670553.

The theory of cavity resonators is outlined, and the three characterizing magnitudes of cavities are defined. The physical properties of cavities and their preparation are described. The time behavior of cavity resonators is given. The susceptibility of failure is considered. The application of superconducting cavities to normal frequencies, detection of low hf intensities, measurement of small power loss, acceleration of particles, and separators are discussed. (J.S.R.)

**20846** MIXED-STATE THERMAL RESISTIVITY IN IRREVERSIBLE TYPE-II SUPERCONDUCTORS. Ward, D. (Univ. of Lancaster, Eng.). Phys. Lett., 28A: 603-4(Feb. 10 1969).

It is shown that the thermal resistivity of an irreversible dirty type-II superconductor may be expressed as a function of magnetic induction. Simple expressions relating resistivity to magnetic induction are suggested. (auth)

**20847** FLUX MOTION IN SUPERCONDUCTORS. Van Beelen, Hugo. Leiden, University of Leiden, 1967. 81p.

Thesis.

Topics covered are: flux pumps and superconducting solenoids, remarks on a moving-flux experiment in superconducting sheets, the motion of vortices in a type-II superconductor under the influence of a transport current, and some measurements on the effective resistance and the Hall angle in type-II superconductors. (M.H.R.)

**20848** FLUX LINE LATTICES IN THE INTERMEDIATE STATE OF SUPERCONDUCTORS WITH GINZBURG–LANDAU PARAMETERS NEAR $1/\sqrt{2}$. Kraegeloh, U. (Max-Planck-Institut fuer Metallforschung, Stuttgart. Univ., Stuttgart). Phys. Lett., 28A: 657-8(Feb. 10, 1969).

Intermediate state structures consisting of flux line lattices have been observed in disks of Pb–1.89 wt % Tl alloys having a Ginzburg–Landau parameter near $1/\sqrt{2}$. (auth)

**20849** RECTANGULAR FLUX LINE LATTICE IN TYPE-II SUPERCONDUCTORS. Obst, B. (Max-Planck-Institut fuer Metallforschung, Stuttgart. Univ., Stuttgart). Phys. Lett., 28A: 662-3(Feb. 10, 1969).

Square flux line lattice and triangular lattices were observed on Pb–1.6 wt % Tl crystals, depending on the crystal orientation. (auth)

**20850** THE SWITCH FROM THIN TO BULK BEHAVIOR OF TYPE-II SUPERCONDUCTING FILMS. Brown, R. W. (Naval Ordnance Lab., Silver Spring, Md.). Phys. Lett., 28A: 663-4(Feb. 10, 1969).

Measurements are reported of the upper critical field for disordered and annealed superconducting tin films. For each film, the switch from thin to bulk behavior is found at a field value independent of state of anneal. (auth)

**20851** SUPERCONDUCTIVITY OF BARIUM UNDER PRESSURE. Wittig, J.; Matthias, B. T. (Univ. of California, San Diego, La Jolla). Phys. Rev. Lett., 22: 634-6(Mar. 31, 1969).

Superconductivity of barium is observed under high volume compression. The high-pressure phase, Ba II, has a $T_c$ somewhat lower than 1.3°K at 55 kbar, $T_c$ sharply rising with increase of pressure. A second solid phase above 140 kbar has a $T_c$ of approximately 5°K. (auth)

**20852** DEVICE FOR MEASURING PRESSURE DROP AND HEAT TRANSFER IN TWO-PHASE HELIUM FLOW. Keilin, V. E.; Klimenko, E. Yu.; Kovalev, I. A. (Inst. of Atomic Energy, Moscow). Cryogenics, 9: 36-8(Feb. 1969).

A device for studying hydrodynamics and heat transfer in helium flow (helium being in two-phase liquid, and supercritical states) is described. Preliminary data on pressure drop and heat transfer in two-phase helium flow are presented. The tube used was about 0.45 mm ID and about 1 m long. The mass flow in the tests ranged from $1.5 \times 10^{-2}$ g/s, the heat flux from 0.02 to 0.5 W/cm$^2$, and quality x (mass vapor fraction) ranged from 0 to 100%. The dependence of $\Delta p/[x\Delta p_v + (1-x)\Delta p_l]$ on x is found to give a convenient form of presentation of experimental two-phase pressure-drop data. (auth) (UK)

**20853** REVIEW OF HEAT TRANSFER TO HELIUM I. Smith, R. V. (National Bureau of Standards, Boulder, Colo.). Cryogenics, 9: 11-19(Feb. 1969).

A summary of information on heat transfer to helium I is given. Correlations are recommended for use in design studies, and the research work required to produce further needed information is outlined. (auth) (UK)

**20854** SIZE DEPENDENCE OF THE SUPERCONDUCTING TRANSITION TEMPERATURE. Naugle, D. G. (Univ. of Maryland, College Park); Glover, R. E. Phys. Lett., 28A: 611-12 (Feb. 10, 1969).

A linear dependence of the superconducting transition temperature on the reciprocal of the sample thickness is reported for amorphous Bi and Ga films having thicknesses from 150 up to several thousand angstroms. Decreasing the thickness lowers the transition temperature. (auth)

**20855** APPLICATION OF THE GENERALIZED LANDAU ANSATZ TO SECOND-ORDER PHASE TRANSITIONS. Stauffer, D. (Max-Planck-Institut fuer Physik und Astrophysik, Munich). Z. Phys., 221: 122-33(1969).

The ansatz of Amit et al. with expansion coefficients which can be nonanalytic functions of either the temperature or the order parameter is used to predict the generalized susceptibility (compressibility) and the surface tension below $T_c$ and the critical isotherm at $T_c$ from the specific heat, the order parameter at the coexistence curve, and the coherence length. The results agree within 50% with experiments on different phase transitions in ferromagnets, classical gages, quantum gases, binary mixtures, and superfluid helium. The ansatz can be written in two different versions; their results differ only by logarithmic factors. (auth)

**20856** EXPERIMENTAL STUDY OF SUPERCONDUCTIVITY IN DEGENERATE SEMICONDUCTORS. Builova, N. M.; Sandomirskii, V. B. (All-Union Inst. for Scientific and Technical Information, Moscow. Radio and Electrotechnical Inst., Moscow). Usp. Fiz. Nauk, 97: 119-29(Jan. 1969). (In Russian).

In contrast to metals, it is relatively easy to change electrophysical properties, such as zonal structure, position of local levels, carrier concentration, etc., of semiconductors by means of deformation, irradiation or other external agents. This is useful for studying the correlation between semiconducting and superconducting properties of semiconductors. Combination of these two properties in the same material is of great interest. The studies revealed the following requirements for the combination of properties: large electron–phonon interaction constant;

large electron (hole) concentration in the conductivity (valence) region; variegated zonal structure; large dielectric permittivity; and large effective mass of the charge carrier. From this, it was concluded that $SrTiO_3^-$, $KTaO_3^-$, GaAs–GaP$^-$, $Bi_2Te_3^-$, and SiC-type semiconductors are most promising. Experimental studies have also been made on the semiconductors GeTe, SnTe, $SrTiO_3$, $(Ba_xSr_{1-x})TiO_3$, $(Ca_ySr_{1-y})TiO_3$ concerning their transition into the superconducting state. 42 references. (TTT)

**20857** ON THE LOW-TEMPERATURE BEHAVIOR OF CONDENSED BOSE SYSTEMS. Kehr, Klaus (Max;Planck-Institut fuer Physik und Astrophysik, Munich). Z. Phys., 221: 291-304 (1969).

A microscopic derivation of the $T^2$ law for the low-temperature behavior of the condensate depletion in an interacting Bose liquid is given using the known T = 0 low-lying single-particle excitations. The $T^2$-term gives no contribution to the order $T^3$ in the microscopic proof of Landau's $T^3$-law for the specific heat of an interacting Bose liquid. (auth)

**20858** THE CONSTRUCTION AND TESTING OF A 68kG MAGNET MADE FROM FILAMENTARY NbTi SUPERCONDUCTING WIRE. Good, J. A.; Hudson, P. A. (Oxford Univ.). Cryogenics, 9: 64-6(Feb. 1969).

A magnet with a working bore of 1.7 cm., outer diameter of 6.8 cm., and winding length of 7.8 cm. was constructed from 2 km (1.6 kg) of Niomase FM 61 filament superconductor. The wire has an overall diameter of 0.375 mm, including insulation, and contains 61 filaments of Nb–44% Ti, each 31$\mu$ in diameter, embedded in high purity copper. The relative stability of the coil compared with a magnet previously made with conventional material is evaluated. (auth) (UK)

**20859** SMALL-SCALE LIQUID HELIUM CRYOSTAT. Croft, A. J.; Thomas, J. O. (Oxford Univ.). Cryogenics, 9: 57-8(Feb. 1969).

A cryostat that is small and light enough to be mounted on the rotating spindle of a vertical Weissenberg camera is described in detail. (UK)

**20860** SUPERCONDUCTIVITY IN THE LEAD–BISMUTH SYSTEM. Malseed, C.; Rachinger, W. A. (Monash Univ., Clayton, Australia). Scr. Met., 3: 139-42(Mar. 1969).

The magnetic behavior of superconducting lead–bismuth alloys (in the range 0 to 56.5 at. % Bi) was correlated with composition and microstructure. Critical fields $H_{c1}$, $H_{c2}$, and $H_{c3}$ were measured. Irreversible magnetic effects are interpreted in terms of the Irie and Yamafuji model, modified in some cases by the existence of a surface barrier for type-II alloys, and in terms of flux-tube energetics and surface sheath currents for type I. (auth)

**20861** SUPERCONDUCTING MANOMETERS FOR HIGH-PRESSURE MEASUREMENT AT LOW TEMPERATURE. Smith, T. F. (Atomic Energy Research Establishment, Harwell, Eng.); Chu, C. W.; Maple, M. B. Cryogenics, 9: 53-7(Feb. 1969).

The use of the superconducting transition temperature of tin as a means for determining pressures up to 100 kbar is discussed and a pressure scale is presented. Pressure scales up to 160 and 40 kbar are also given, based on lead and zinc, respectively. (auth)

**20862** FORCE-COOLED SUPERCONDUCTING COIL. Keilin, V. E.; Klimenko, E. Yu.; Kovalev, I. A.; Samoilov, B. N. (Kurchatov Atomic Energy Inst., Moscow). Cryogenics, 8: 397-8(Dec. 1968).

In order to understand the hydrodynamics and current stability features of such systems, a model of a forced-cooled superconducting coil (60 mm ID, 160 mm OD, and 230 mm long) was constructed and tested. (UK)

**20863** STABLE OPTIMIZED SUPERCONDUCTING SPLIT COILS. Agureev, V. N.; Keilin, V. E.; Klimenko, E. Yu.; Samoilov, B. N. (Kurchatov Atomic Energy Inst., Moscow). Cryogenics, 9: 26-32(Feb. 1969).

A superconducting system with a field strength of about 50 kOe in a 20-cm bore is described. The system, with a total weight of 260 kg, consists of two coils divided into radial and axial sections; the axial gap between coils can be changed. The winding is made of stabilized copper strip into which wires of Nb–50% Zr alloy are inserted. In order to minimize the total weight, as well as the weight of superconductor, the winding is self-consistent in regard to critical current and to stability. The number of wires ranges from 20 to 4 and the cross section of the strip from 6.5 to 4 $mm^2$, respectively. In preliminary tests a field of 47 kOe was achieved at a stable current of 575 A (without superconducting-to-normal transition). (auth) (UK)

**20864** FLUX FLOW IN MATERIALS WHERE $\kappa \sim 1$. Hudson, W. R.; Jirberg, R. J. (Lewis Research Center, Cleveland). Solid State Commun., 7: 429-31(Feb. 1969).

The Kim–Anderson flux flow theory is investigated for materials with $\kappa \sim 1$. The analysis yields the spectrum of the number of pinning sites with a particular pinning force. (auth) (UK)

**20865** ON SOME IDENTITIES FOR GREEN'S FUNCTIONS IN THE HYDRODYNAMICAL APPROXIMATION. II. SUPERFLUID. Petru, Z. K. (Univ. of Wroclaw). Acta Phys. Pol., 35: 57-9(Jan. 1969).

After the calculation of Green's function, with the help of the hydrodynamic equations for the Bose superfluid, it is demonstrated that they are connected by formulas, derived earlier by means of the gauge transformation. (auth)

**20866** GREEN'S FUNCTIONS FOR THE BOSE SUPERFLUID AND THE RELATIONS BETWEEN KINETICAL COEFFICIENTS. Petru, Z. K. (Univ. of Wroclaw). Acta Phys. Pol., 35: 49-56 (Jan. 1969).

The Green's functions are obtained with the help of the hydrodynamic equations with viscous terms and from the formulas connecting average values of dynamic variables with retarded or advanced thermodynamic Green's functions. From the relations between the advanced and retarded Green's functions, the relations for some kinetic coefficients are obtained. (auth)

**20867** MECHANISM AND KINETICS OF GROWTH OF THE SUPERCONDUCTING COMPOUND $Nb_3Sn$. Old, C. F.; Macphail, I. (Atomic Energy Research Establishment, Harwell, Eng.). J. Mater. Sci., 4: 202-7(Mar. 1969).

A study was made of the mechanism and kinetics of formation of $Nb_3Sn$ from the elemental components. The $Nb_3Sn$ forms partly by diffusion and partly by a solution/deposition mechanism which depends on thermal gradient mass transfer. The effect of this is to modify the growth equation to $x = kt^{0.36}$ over the temperature range 950 to 1150°C. The temperature dependence of these two processes, given by the difference between the activation energies for diffusion and solution, is −9.7 kcal/g atom (−0.42 eV/atom), so that the thickness of the $Nb_3Sn$ layer produced in any given time decreases with increasing temperature. Various experimental factors are discussed in terms of their influence on the rate of growth of the layer. (auth) (UK)

**20868** ELECTRON INTERFEROMETRIC MEASUREMENT OF THE MAGNETIC FLUX TRAPPED IN A SUPERCONDUCTING HOLLOW CYLINDER. Wahl, H. (Univ., Tuebingen, Ger.). Optik, 28: 417-20(Jan. 1969). (In German).

In an electron interferometer, a region 40 $\mu$m in width between two coherent partial waves was kept free from electrons by an appropriate diaphragm. A hollow Pb cylinder was arranged so that its one end was situated in the center of this region while the other end was far outside. This cylinder was made superconducting by cooling it in an outer magnetic field parallel to its axis so that a magnetic flux was captured after switching off the outer field, this captured flux depending on the cylinder cross section and the offered field. The interference fringes which were parallel to the cylinder axis in the regions of constant flux were found to be shifted in a transition zone near the end of the cylinder by an amount from which the captured flux could be directly derived. This directly observable captured flux proved to be slightly smaller than the flux offered before cooling. Besides the transition from the normal to the superconducting state near the cylinder end smaller fringe shifts were sometimes observed at places where short normal conducting regions were included between superconducting ones. When the Pb cylinder was warmed up again beyond the transition temperature, the transition zone could be watched moving swiftly along the cylinder starting from its end. (auth)

**20869** POWER DISSIPATION AND FLUX JUMPS IN HARD SUPERCONDUCTING SLABS, TUBES, AND SOLENOIDS. Morton, N. (Univ. of Salford, Eng.). Cryogenics, 8: 372-7(Dec. 1968).

Calculations of local power dissipation in hard superconductors have been published previously. Calculations of the total power dissipation within various samples were performed in this study, making a simple assumption that enables the occurrence of the observed series of flux jumps to be predicted with reasonable accuracy. (auth) (UK)

**20870** SOLENOIDS OF UNSTABILISED SUPERCONDUCTING CABLE. Al'tov, V. A.; Zenkevich, V. B.; Karasik, V. R.; Sychev, V. V.; Tovma, V. A. (Inst. of High Temperatures, Moscow). Cryogenics, 8: 390-2(Dec. 1968).

The advantages and disadvantages of using multistrand cable are discussed briefly and, in order to determine the optimum design, a series of experimental solenoids with appreciably different dimensions were prepared and tested. (UK)

**20871** RESISTIVITY AND PENETRATION DEPTH IN SUPERCONDUCTING THIN FILMS. Tsushima, T.; Sakai, K.; Tsuka-

hara, S.; Kokubun, K.; Ito, A.; Nagano, H. (Tokyo Univ.). Cryogenics, 8: 389-90(Dec. 1968).

The effect of imperfections on the resistivity and critical temperature of superconducting lead films is reported. The films, prepared by vacuum deposition, were from 990 to 4390 Å thick. (UK)

**20872** MAGNETIC FIELD ENHANCEMENT IN SUPERCONDUCTING TUBES. Young, E. F.; Gayley, R. I. (State Univ. of New York, Buffalo). MonJ. Phys. Chem. Solids, 30: 175-81(Jan. 1969).

The magnetic behavior of tubes of superconducting material cooled in an axial magnetic field was studied in an attempt to understand the increase in field strength that occurs in the holes of these tubes. It was found that the magnitude of this effect is determined largely by the shape and size of the tube and that it is qualitatively the same for a variety of materials. The results show that what is characteristic of a given tube is the amount of flux that will move into the hole rather than the field increase that will occur. (auth) (UK)

**20873** ORIENTATION AND TEMPERATURE-DEPENDENT SUPERCONDUCTING PROPERTIES IN NIOBIUM AND VANADIUM SINGLE CRYSTALS. Williams, I.; Court, A. M. (National Physical Lab., Teddington, Eng.). Solid State Commun., 7: 169-71(Jan. 1969).

Analogous anisotropies in $\kappa_1$ and $\kappa_2$ were investigated in Nb and V single crystals in the range 1.7 to 4.2°K. A similar, but inverted anisotropy appears at low temperature in the surface critical current. (auth) (UK)

# Plasma and Thermonuclear Physics

**20874** (SIT-2813-47) ANNUAL PROGRESS REPORT. Rogers, Kenneth C.; Motz, Robin O. (Stevens Inst. of Tech., Hoboken, N. J. Dept. of Physics). Feb. 1969. Contract AT-(30-1)-2813. 25p. (SIT-232). Dep. CFSTI.

This work is a continuation of the studies initiated in 1964 of a low-beta, magnetically confined, quiescent plasma column (Q plasma). The work consisted of four phases: (a) completion of a study of cross-field plasma loss in a single-ended potassium Q plasma; (b) completion of construction of a new Q machine, designed specifically for the generation of and optical studies of a barium Q plasma; (c) experimental optical studies of a barium Q plasma; and (d) theoretical studies of the atomic and optical properties of the $Ba^+$ ion. (auth)

**20875** PROBLEMS OF PROPULSION AND RE-ENTRY. XVIIth INTERNATIONAL ASTRONAUTICAL CONGRESS, MADRID, 1966. PROCEEDINGS. Lunc, Michal; Contensou, P.; Duboshin, G. N.; Hilton, W. F. (eds.). New York, Gordon and Breach, Inc., 1967. 433p. (In Several Languages). (CONF-661051).

Separate abstracts were prepared for 4 of the 40 included papers. The remaining papers were not in scope of NSA and hence, omitted. (M.O.W.)

*For abstracts of individual papers see: 20744, 20904, 20949, and 21535.*

**20876** QUASI-STATIC THEORY OF ANTENNA IN A MAGNETOACTIVE PLASMA IN THE PRESENCE OF PLASMA RESONANCE. Chugunov, Yu. V. (Scientific Research Inst. of Radiophysics, Moscow). Izv. Vyssh. Ucheb. Zaved., Radiofiz., 11: 1829-38(1968). (In Russian).

The boundary problem is solved in a quasi-static approximation for the charged metallic ellipsoid of rotation placed in a magnetoactive plasma in the frequency range where a plasma wave may be excited. The applicability conditions of quasi-static approximation are discussed. (auth)

**20877** INSULATED CYLINDRICAL ANTENNA IMMERSED IN A COMPRESSIBLE PLASMA. Galejs, Janis (Sylvania Electric Products Inc., Waltham, Mass.). Radio Sci., 4: 269-78(Mar. 1969).

A cylindrical antenna is embedded in a dielectric cylinder, which is surrounded by a compressible isotropic electron plasma. The antenna impedance is formulated variationally by considering the effects of surface waves supported by the antenna structure. The surface waves alter the antenna current distribution for frequencies near the plasma frequency, but their amplitude is decreased as the thickness of the antenna insulation increases. The antenna solution is verified by examining the electric surface fields excited by the approximated antenna current distributions, and the results are compared with other numerical solutions. (auth)

**20878** GENERAL REPORT ON THE ACTIVITY IN ITALY IN THE FIELD OF PLASMA PHYSICS FOR THE YEAR 1966-67. Bocchieri, P. (Univ., Pavia, Italy. GNEQP, Pavia, Italy). Nuovo Cim., Suppl., 6: 1049-60(1968). (In Italian).

The plasma studies in Italy were concentrated on plasma physics with study of instability and abnormal scattering in magnetic fields, controlled thermonuclear fusions with pulse studies on the production of high density partially confined hot plasmas, and applications on the direct conversion of heat into electrical energy. A complete bibliography of works published in 1966-67 is appended. (J.S.R.)

## Confinement and Heating

*Refer also to abstracts 20889, 20931, 20932, and 20946.*

**20879** (GA-9003) CONTROLLED THERMONUCLEAR RESEARCH PROGRAM. Summary Progress Report, July 1, 1967-July 31, 1968. Miller, P. H. Jr.; Ohkawa, T. (Gulf General Atomic, Inc., San Diego, Calif.). Sept. 15, 1968. Contract AT-(04-3)-167. 102p. Dep. CFSTI.

Experiments with the quadrupole device were started and were essentially completed during fiscal year 1968. The results are summarized. The data from both quadrupole and octupole devices show good confinement of plasma. The plasma lifetime is at least one order of magnitude greater than Bohm time. (M.O.W.)

**20880** BINARY COLLISION LOSSES IN STELLARATORS. Gibson, A.; Mason, D. W. (Culham Lab., Eng.). Plasma Phys., 11: 121-9(Feb. 1969).

There can exist a class of particles in stellarator fields for which the cancellation of the toroidal drift is incomplete. These localized particles, reflected in the gradients of the helical field, can drift through the separatrix of particular stellarators no matter how strong the field; they form a loss region in velocity space. The loss of plasma due to binary collision scattering into this loss region in the absence of electric fields, is calculated. The possibility of confining a plasma with reactor parameters in the presence of this loss is examined. (auth) (UK)

**20881** DETERMINATION OF STELLARATOR EQUILIBRIA USING GUIDING-CENTER EQUATIONS. Dobrott, Donald R.; Johnson, John L. (Princeton Univ., N. J.). Plasma Phys., 11: 211-21(Mar. 1969).

Stellarator expansion techniques, previously used to obtain an asymptotic toroidal equilibrium for the ideal scalar-pressure fluid equations, are applied to the guiding-center model. An explicit formulation for determining the asymptotic solution is given in terms of a small parameter. The parameter measures the magnitude of the magnetic fields associated with toroidal curvature, currents in the helical conductors, plasma pressures and currents, with respect to a zero-order uniform magnetic field. (auth) (UK)

**20882** NONADIABATIC AND STOCHASTIC MECHANISMS FOR CYCLOTRON RESONANCE TRAPPING AND HEATING IN MIRROR GEOMETRIES. Lichtenberg, Allan J. (Univ. of California, Berkeley); Schwartz, Marvin J.; Tuma, David T. Contract AF33(615)-3524. Plasma Phys., 11: 101-16(Feb. 1969).

Experiments on rf cyclotron resonance capture and heating were performed. Previously reported work was extended and considerably higher temperatures (~100 keV at peak compression of 45 kG) were found. A clear transition between the Gaussian and Maxwellian energy distribution was found, as predicted by the theory. The absolute magnitude of the stochastic heating (~8 keV at the end of the heating pulse at cyclotron resonance of 3.7 keV) was in reasonable agreement with the theoretical prediction. The number of trapped particles was found to be greater than $10^{12}$. (auth) (UK)

**20883** EFFECT OF AN ELECTRIC FIELD ON WEAKLY IONIZED GAS. III. INFLUENCE OF INELASTIC COLLISIONS ON THE ELECTRON DISTRIBUTION FUNCTION AT LOW ENERGIES. Peyraud, Nelly (Laboratoire de Physique des Plasmas, Orsay, France). J. Phys. (Paris), 29: 997-1004 (Nov.-Dec. 1968). (In French).

A study was made previously of the balance between heating by an electric field and losses by elastic and inelastic collisions on neutral molecules of homogeneous gas weakly ionized and optically thin for all transitions. In this second part of the work, the electronic distribution function is determined for energies lower than the upper threshold; elastic and inelastic collision frequencies are described by elementary functions, the choice of which is justified using atomic hydrogen as example. (auth)

**20884** STOCHASTIC MODEL OF ELECTRON CYCLOTRON HEATING. Grawe, H. (Oak Ridge National Lab., Tenn.). Plasma Phys., 11: 151-62(Mar. 1969).

The energy gained by an electron during one transit of an ideal-

ized one dimensional magnetic mirror field B in the presence of a given microwave electric field is calculated analytically. The heating rate is defined as this energy gain over the transit time. It depends on the initial energy and the position of the turning point of the electron. The heating rate for relativistic electrons not crossing the resonance surfaces (on which the microwave frequency equals the local nonrelativistic electron gyrofrequency) can be comparable to that of "resonant electrons." A comparison of the heating rate and energy loss rates from multiple collisions and radiation suggests an equilibrium at energies of $10^2$ to $10^3$ keV, depending on the mirror ratio, microwave field strength and frequency, and the density of the cold-electron group responsible for the collisional energy losses. The fraction of electrons heated to this equilibrium energy is calculated. The results are in good agreement with the experimental measurements. (auth) (UK)

## Diagnostics

*Refer also to abstract 20043.*

**20885** (CEA-CONF-1036) COLLECTIVE SCATTERING OF LASER LIGHT AT 90° FROM A NONCYLINDRICAL Z DISCHARGE. Baconnet, J. P.; Cesari, G.; Coudeville, A.; Watteau, J. P. ([Commissariat a l'Energie Atomique, Limeil-Brevannes (France). Centre d'Etudes]). [nd]. 13p. (In French). (CONF-680831-1). Dep.

From Conference on Plasma Diagnosis, Culham, England.

The electron density and temperature of a deuterium plasma were measured by scattering of laser light, due to the fluctuations of electron density. The spectrum of the scattered light depends on the value $\alpha = 1/(|\vec{k}_0 - \vec{k}_1|) \cdot \lambda_D$, where $\vec{k}_0$ and $\vec{k}_1$ are the incident and scattered wave vectors and $\lambda_D$ is the Debye length. Beginning with a 20-kV, 3-kj condenser, a linear discharge is produced in a pyrex revolution chamber, having a central bulge and two symmetric constrictions. A 100-MW ruby laser is used and the scattered light is observed perpendicularly to the incident beam. A part of the scattered light gives the intensity of all the scattered spectrum, whereas the other is analyzed by a spectroscope. The resolution of the spectrum is done by using 10 channels with glass fibers, coupled with 10 photomultipliers and oscilloscopes. The electron component of the measured spectrum, as a function of $\alpha$ and $T_e$, is compared to the theoretical profiles of Salpeter. The direct comparison is tedious and lacks precision. A computer treatment utilizing a least-squares method gives directly the value of $\alpha$ and $T_e$ from the experimental points. $N_e$ is then deduced from $\alpha = C\ (N_i/T_e)^{1/2}$. An independent verification of the measurements was made from the value of $N_e$ deduced from the total intensity of the scattered spectrum; the calibration was done by Rayleigh scattering in a neutral gas. The values obtained were $T_e = 2.5 \pm 0.3$ eV, $N_e = 5 \pm 0.5 \times 10^{16}$ cm$^{-3}$, $\alpha = 1.4$, when the initial deuterium pressure is $10^{-1}$ torr. The addition of impurities modifies these data. (tr-auth)

**20886** (CEA-CONF-1059) MEASUREMENT OF WAVE-NUMBER SPECTRA. Perceval, F.; Bousque, J. C.; Olivain, J.; Parisot, M.; Perulli, M. ([Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires]). [1968]. 14p. (In French). (CONF-680831-4). Dep.

From Conference on Plasma Diagnosis, Culham, England.

In order to measure wave lengths in an ionized medium, an intercorrelation product between the signal collected by a fixed probe and that of a mobile probe is obtained. To determine the different modes constituting signals from several simultaneous propagation modes, an apparatus that makes a Fourier analysis of signals of this type was developed. The apparatus is based on the calculation of the Fourier transform of a signal delivered by an interferometer. The apparatus was tested by calculating the Fourier spectrum of pure sinusoids, mixtures of sinusoids, and damped sinusoids. The apparatus was used to measure the space structure of waves being propagated either in a plasma column or in a double-beam system. (J.S.R.)

**20887** (CEA-CONF-1060) ULTRAFAST DIAGNOSTIC SPECTROSCOPY OF A PLASMA CREATED BY FOCUSING A LASER BEAM ON A GAS. Cesari, C.; Consoli, T.; Jacquot, C.; Slama, L.; Stevenin, P. ([Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires]). June 20, 1968. 38p. (In French). (CONF-680831-2; IGn/RT-604). Dep.

From Conference on Plasma Diagnosis, Culham, England.

The time evolution of the density and temperature of a plasma created by focusing a ruby laser beam on a vessel containing argon at a pressure between 300 and 760 torr was studied. The temperature was evaluated by comparison of the intensities of two emission lines of the plasma, and the density was measured from the Stark effect. A spectroscopic ensemble was used, composed of two light amplifiers operating in streak sweep and associated with a spectrograph that makes it possible to obtain the evolution of the profile of the emission lines directly on a photographic plate. The evaluation of the density relied on the numerical results of the Griem quantum theory, in which the validity limit is placed toward high electron density. The validity of the temperature measurement is discussed, analyzing the hypothesis of local thermodynamic equilibrium in which the limits appear toward the low densities. The transitory character of the plasma necessitates comparison of the relaxation times associated with physical processes which register their evolution. (J.S.R.)

**20888** (NP-17811) TEMPERATURE DISTRIBUTION IN A HYDROGEN PLASMA COLUMN EMBEDDED IN A STRONG MAGNETIC FIELD. Rijnhuizen Report 68-47. Rem, J.; Weenink, M. P. H. (Stichting voor Fundamenteel Onderzoek der Materie, Jutphaas (Netherlands). Instituut voor Plasma-Fysica). Oct. 1968. 22p. Dep.

It is shown that the temperature distribution in an arc in a strong magnetic field can be expressed in an analytic form under "certain" assumptions. The model to be investigated is a cylindrical, quasi-neutral, fully ionized plasma which is placed in a magnetic field directed along the axis of the cylinder (the z axis). The plasma is in a stationary state and in local thermal equilibrium. The magnetic field is taken to be strong, i.e., $\omega_e\tau_e$ and $\omega_i\tau_i$, the products of the cyclotron frequency and the collision time for the electrons and ions, respectively, should be large compared to unity. The current along the column is assumed to be the only energy source. It should be small enough, however, to assure that the azimuthal component of the magnetic field $B_\phi$, which it creates, is negligible compared to the applied z-field ($B_\phi \ll B_z$). The electric field which sets up this current is independent of the radius r. It is shown that there exists a simple relationship between the density n and the temperature T combined with which the energy equation yields a nonlinear differential equation for the temperature. This equation can be transformed into an elementary linear one and solved exactly. The last section contains a discussion on the validity of the result and a comparison of it with the more complete results obtained with the help of a computer. (auth)

**20889** (SIT-2582-27) EXPERIMENTAL INVESTIGATION OF CUSPED CONTAINMENT GEOMETRIES, CHALICE. Semiannual Report, September 1, 1968–February 28, 1969. Yevick, George J. (Stevens Inst. of Tech., Hoboken, N. J. Dept. of Physics). Contract AT(30-1)-2582. 75p. (SIT-233). Dep. CFSTI.

During the past six months, one learned with some certainty that the plasma in the cusp is over 100 eV for at least 5 microseconds and densities greater than $3 \times 10^{16}$ per cm$^3$ prevail for times greater than 20 microseconds. This data was obtained by direct observation through the cusp with a Mach–Zehnder interferometer and measuring the line intensity of $C_V$ emitted from the cusp. Temperature and density measurements by Thompson scattering and Michelson interferometry are discussed. (auth)

**20890** (UCRL-Trans-1388) MEASUREMENT OF HIGH-FREQUENCY FIELD STRENGTH IN A PLASMA VIA THE STARK EFFECT. [PART] II. Lifshits', E. V.; Krivulia, S. A.; Us, V. S. Translated by J. E. S. Bradley for Univ. of California Lawrence Radiation Lab., Berkeley, from Ukr. Fiz. Zh., 8: 1328-34(1963). 20p. Dep. CFSTI.

An abstract for the original paper appeared earlier in NSA 18: 17188. (M.O.W.)

**20891** APPLICATION OF LINE-REVERSAL METHOD TO SHOCK-HEATED MHD PLASMA. Yamashita, Iwao. Kikai Shikenjo Shoho, 23: 11-23(Jan. 1969). (In Japanese).

A spectroscopic pyrometer based on spectral line reversal was framed for the purpose of measuring the temperature of the plasma for MHD power generation produced in a pressure-driven shock tube. The spectral lines used are the resonance lines of potassium atoms seeded in argon gas. The spectral line reversal method is reviewed critically and the physical meaning of the measured temperature is considered, taking account of the effects of the imprisonment of resonance radiation, and collisional excitation and quenching by neutral atoms and electrons. It is concluded that the temperature measured with the potassium resonance lines (7645, 7699 Å) corresponds to the electron temperature in the MHD plasma. The errors of temperature determination originating from the noises of photomultipliers and the beam width of the oscilloscope are expressed as a function of effective emissivity and temperature, and are discussed quantitatively in typical conditions. The broadening and total absorption of lines are considered in order to estimate the effective emissivity which is related to the accuracy of temperature determination and also measurement of a quantity of seeded alkali-metal atoms. These properties calculated in the shock tube experimental conditions suggest that the effective

emissivity is so large that it is possible to measure the temperature with fairly good accuracy. (NSA of Japan)

**20892** PROBE MEASUREMENTS IN dc AND hf GAS DISCHARGES. Gupta, G. L.; Gupta, D. R. (Univ. of Jodhpur, India). Indian J. Phys., 42: 328-9(May 1968).

Experiments have been conducted in the dc plasma of argon gas (branded as spectrally pure) in the pressure range of $62 \times 10^{-4}$ to $77 \times 10^{-2}$ mm Hg using a tungsten wire probe of length 3.45 cm and diameter 0.22 mm. The diameter of the discharge tube used was 6.0 cm. Results were compared with previous data. (M.O.W.)

**20893** DETERMINATION OF TEMPERATURE PULSATIONS IN CROSS SECTION OF PLASMA JETS. Kukonin, V. E. (Inst. of Heat and Mass Exchange, Minsk). Inzh.-Fiz. Zh., 16: 145-7 (Jan. 1969). (In Russian).

The method is described and results are presented of composition of radial distribution of temperature pulsations in the cross section of a plasma jet from pulsations of temperatures measured along chords. (auth)

**20894** RF IMPEDANCE METHOD FOR DETERMINING THE ELECTRON DENSITY AND COLLISION FREQUENCY IN A PLASMA. Basu, J.; Sen, C. (Saha Inst. of Nuclear Physics, Calcutta). Indian J. Pure Appl. Phys., 7: 75-6(Jan. 1969).

An rf impedance method for plasma diagnostics is outlined. It is shown that the electron density and collision frequency in a plasma can be determined by measuring, at two frequencies, the impedance between two plane probes immersed in the plasma and biased with a suitable voltage. (Indian Sci. Abstr.)

**20895** GENERAL METHOD OF CALCULATION OF COEFFICIENTS OF TRANSMISSION AND COMPLEX REFLECTION FOR A DIELECTRIC FILM WITH A PERMITTIVITY GRADIENT. APPLICATION TO PLASMA DIAGNOSTICS. Bottreau, Andre; Duparc, Jean Hardouin (Faculte des Sciences, Bordeaux. CNRS, Talence, France). Compt. Rend., Ser. A, B, 268: 74-7(Jan. 6, 1969). (In French).

A calculation program is used to obtain the coefficients of transmission and complex reflection for the Maxwell equations in which the permittivity is a function of the position. Application is made for plasmas in the case of various simple distributions of the electron density. (tr-auth)

**20896** PROBE MEASUREMENTS OF ELECTRON TEMPERATURE IN FLAME PLASMAS. Sahni, O. (Faculte des Sciences, Orsay, France). J. Phys., D (London), 2: 471-3(Mar. 1969).

Some special factors involved in probe measurements which could lead to a gross over-estimation of the electron temperature in flames are discussed. The importance of the proper positioning of the probes with respect to secondary reaction zones is demonstrated for atmospheric flames. An attachment mechanism, operative below 373°K, is proposed to account for the high values of electron temperature measured in hydrocarbon flames by earlier workers using water-cooled probes. (auth) (UK)

**20897** CONDUCTIVITY PROBE FOR TENUOUS PLASMAS. Holmquist, Fred N. (General Electric TEMPO, Santa Barbara, Calif.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J., 7: 205-10 (Feb. 1969).

The behavior of a new-type conductivity probe was investigated both theoretically and experimentally. The probe consists of three coil-wound, coaxial ferrite toroids equally spaced and mounted in a row. The probe acts like a transformer. The conducting plasma acts as a single-turn coil which threads around and through the two outer primary toroids and the central secondary toroid. The amplitude and phase of the secondary coil voltage determines the complex conductivity. When the sheath thickness is small compared to the dimensions of the probe, its complicating effect vanishes and the conductivity is described by the simple sheathless probe theory. Techniques for minimizing unwanted voltages in the secondary coil, minimum measurable electron and ion densities, and the amenability of the probe for investigating charged-particle clusters are discussed. (auth)

## *Kinetics (General)*

*Refer also to abstract 20052.*

**20898** (NP-17786) INVESTIGATION OF THE STABLE STATE OF AN EVACUATED PLASMA IN A Q-MACHINE. Preprint 208. Gurevich, A. V.; Salimov, R. A.; Buchel'nikova, N. S. (Akademiya Nauk SSSR, Novosibirsk. Institut Yadernoi Fiziki). 1968. 20p. (In Russian). Dep.

An investigation was made of the stable state of a thermally ionized plasma in a Q-machine. A case is examined theoretically when the plasma potential is negative. The distribution functions of electrons and ions have been found. Expressions have been obtained for the plasma potential, the floating potential of the electrode and its volt-ampere characteristic. The results of the calculation are compared with the experiment. (auth)

**20899** SYNCHROTRON DECELERATION OF ELECTRONS IN A PLASMA AND THE GENERATION OF ELECTROMAGNETIC RADIATION. Blanken, R. A. (Princeton Univ., N. J. Massachusetts Inst. of Tech., Cambridge); Kuckes, A. F. Plasma Phys., 11: 321-31(Apr. 1969).

Electromagnetic radiation generated by electrons with several hundred keV of energy gyrating in a dense magnetized plasma was studied both experimentally and theoretically. Radiation with an intensity several thousand times greater than that generated by the single particle synchrotron process was observed at the second cyclotron harmonic if the background plasma was sufficiently dense. A critical condition for the generation of this radiation is that the upper hybrid resonance frequency of the background plasma be greater than the observation frequency. The observations are related to a relativistic phase trapping of the energetic electrons by an electromagnetic wave propagating perpendicular to the magnetic field. The plasma instability mechanism proposed is in good agreement with the observations. (auth) (UK)

## *Kinetics (Experimental)*

**20900** (IAE-1619) ELECTRICAL CONDUCTIVITY AND ENERGY BALANCE IN A NONEQUILIBRIUM PLASMA. II. VAPORS OF NEON-CESIUM, KRYPTON-CESIUM, AND XENON-CESIUM MIXTURES). Volkov, Yu. M.; Malyuta, D. D. (Akademiya Nauk SSSR, Moscow. Institut Atomnoi Energii). 1968. 20p. (In Russian). Dep.

Results are given of an experimental investigation of a nonequilibrium plasma of a pulsed discharge in the mixtures of inert gases with cesium; in particular, the electron-energy balance and electrical conductivity of such a plasma are examined and also the times for reaching ionization equilibrium in the pure inert gases and "critical" parameters of the current-conducting channel. A brief review is given of the existing methods of calculating the electrical conductivity of the plasma with intermediate stages of ionization. The experimental results obtained are compared with the calculations by different methods with the aim of selecting from among them one most convenient for the engineering calculations. A simple method of calculation is suggested which does not require the employment of electronic computers and which provides a sufficient accuracy in the region of the degrees of ionization being examined. (JPRS)

**20901** (IAE-1626) SOME ELECTRICAL PROPERTIES OF DENSE PLASMA. Alekseev, V. A. (Akademiya Nauk SSSR, Moscow. Institut Atomnoi Energii). 1968. 8p. (In Russian). Dep.

This work sets forth experimental data on the measurement of electrical conductivity of cesium in the supercritical region. It is shown that in a gaseous state cesium may have high conductivity approaching that of metals. A. M. Dykhne (1964) stated a hypothesis on the feasibility of creating high-density plasma with positive and negative ions, in which conductivity is determined by the tunnel jump of electron. An attempt is undertaken in the work to obtain such a plasma by making use of a jet of sodium and chlorine vapor. Data are cited on the measurement of electrical conductivity of such a plasma. The considerable interest which has appeared of late in regard to dense plasma was brought about first of all by the feasibility of creating a working substance with high conductivity for MHD transformation and by an urge towards a more thorough understanding of the conductivity of a condensed state of material. A special feature of such a plasma is the existence of quantum effects brought about by the overlap of the wave functions of the electrons. (JPRS)

**20902** (N-68-37052) INTERFEROMETRIC STUDY OF THE NONEQUILIBRIUM SHOCK REFLECTION PROCESS AND THERMAL LAYER IN IONIZING ARGON. Kuiper, Ralph A. (Stanford Univ., Calif. Dept. of Aeronautics and Astronautics). Aug. 1968. 144p. (NASA-CR-97252; SUDAAR-353). CFSTI.

Two-wavelength, time-resolved interferograms provide time history measurements of the thermodynamic properties behind the reflected shock wave in ionizing argon and an informative flow visualization of the shock reflection process, including the nonequilibrium wave interactions resulting from the onset of ionization behind both the incident and reflected shocks. Argon ionization relaxation times obtained from the interferograms are correlated and compared with previous measurements over a range of shock speeds from 2.9 to 5.5 km/sec. Density and electron concentration profiles are obtained in the ionized, end wall boundary layer from the interferograms. Upon comparison, it

is found that the experimental electron concentrations remain considerably higher in the boundary layer than predicted by theory. The discrepancy is attributed primarily to nonequilibrium effects which are not accounted for in the theoretical treatment. From a comparison of theory and preliminary boundary-layer experiments when no ionization is present, a value of $\nu = .75$ for the temperature exponent is obtained when the thermal conductivity for neutral argon is assumed proportional to $T^{\nu}$. (auth) (STAR)

**20903** (UCRL-17601) TRANSPORT OF A PARTIALLY IONIZED PLASMA ACROSS A MAGNETIC FIELD. Warren, Laird (California Univ., Berkeley. Lawrence Radiation Lab.). Sept. 30, 1968. Contract W-7405-eng-48. 251p. Dep. CFSTI. Thesis.

Experiments were made on the partially ionized secondary plasma of a magnetically collimated hollow-cathode arc discharge. Experiments were done in He, $H_2$, Ar, and $N_2$ for neutral pressures of 1.5 to 7 mtorr with a magnetic field of 300 to 1680 G in a diffusion chamber 58.2 cm long and 20 cm in diameter. The plasma produced falls off radially from a density of $10^{13}$ to $10^{14}$ $cm^{-3}$ with $kT_e \approx 8$ eV in the center of the discharge to $10^{10}$ to $10^{11}$ $cm^{-3}$ with $kT_e < 0.5$ eV near the wall. Detailed measurements on the plasma density, potential, and electron temperature as a function of spatial position have been made with Langmuir probes for a variety of experimental conditions. From these measurements the values of the diffusion coefficients and electric fields are estimated, and the particle transport rates and particle accumulation rates due to various processes are deduced and compared. The transport of this partially ionized plasma across a magnetic field is determined by diffusion, mobility, and convection. Radial diffusion due to charged-particle collisions for the ions is the same order of magnitude as diffusion by collisions with neutrals, and for the electrons is much larger than neutral collisional diffusion. When the concentric ring end electrodes of the system are electrically grounded, there is a radial ion transport due to mobility in the presence of a radial electric field which is much larger than the transport due to diffusion. In addition, convection due to azimuthal electric field and density fluctuations gives a radial ion transport comparable to the other radial transport processes. When the end electrodes are electrically isolated the radial electric field becomes negligible. However, small transverse electric fields are established which cause the plasma to drift in a preferred direction, producing an azimuthally asymmetric plasma distribution which is sensitive to small changes in magnetic field alignment. A change in any externally applied transverse magnetic field of the order of 0.0004 $B_z$ will cause the asymmetry to change markedly. (auth)

**20904** PLASMA ROTATION IN A PULSED INDUCTIVE ACCELERATOR. Dailey, C. L. (TRW Systems, Redondo Beach, Calif.). pp 253-60 of Problems of Propulsion and Re-entry. Lunc, Michal (ed.). New York, Gordon and Breach, Inc., 1967.

From 17th International Astronautical Congress, Madrid. See CONF-661051.

An experimental investigation was made of the acceleration mechanism in the current layer that forms when a strong magnetic field moves at high speed into an initially stationary field-free plasma. The current layers studied are about one-half the thickness of the ion gyro radius. The presence of ion current, observed with probes, is explained as the result of ion acceleration by the induced azimuthal electric field. (M.O.W.)

**20905** DYNAMIC SHEATH GROWTH IN A MERCURY PLASMA. Varey, R. H.; Sander, K. F. (Univ. of Cambridge, Eng.). J. Phys., D (London), 2: 541-50(Apr. 1969).

The growth of a positive ion sheath was measured in a mercury plasma of density $10^{10}$ to $10^{11}$ $cm^{-3}$. The sheath was formed on a plane electrode, the potential of which changed at a rate of up to 3 kv $\mu s^{-1}$ and reached a maximum value of 10 kV. The thickness of the sheath is compared with various theoretical models and good agreement is found between experiment and theory. An expression is derived for the current flowing in the dynamic sheath system and compared with experiment. (auth) (UK)

**20906** COLLECTIVE INTERACTIONS IN A FAST THETATRON DISCHARGE. El-Khalafawy, T. A.; Souprunenko, V. A.; Ternopol, A. M.; Khafis, L.; Yousef, A. M. (Atomic Energy Establishment, Cairo). Plasma Phys., 11: 237-45(Mar. 1969).

An excitation mechanism and plasma wave dissipation in a fast thetatron discharge have been investigated in the work presented. Plasma waves are shown to be excited due to anisotropy of the electron energy occurring as a result of electrons being accelerated by the azimuthal electric field. The mechanism of nonadiabatic inductive acceleration of electrons without the formation of an equilibrium orbit seems to be the most probable one. (auth) (UK)

**20907** IONIZATION AND CURRENT GROWTH IN AN E x B DISCHARGE. Rasmussen, C. E.; Barbian, E. P.; Kistemaker, J. (FOM Inst. for Atomic and Molecular Physics, Amsterdam). Plasma Phys., 11: 183-95(Mar. 1969).

The discharge buildup in a long homopolar-type rotating plasma device with mirror-shaped magnetic field was investigated by time-resolved measurements of the current and potential distributions, in combination with image-converter camera pictures. As filling gases, $H_2$, $N_2$, He, Ne and Ar at $10^{-2}$ mm Hg were used; the ratio of cyclotron and collision frequency for electrons was much larger than unity. An exponential increase of the current was observed between $10^{-1}$ and $10^{2}$ A, within a wide range of E/B. The rate of current growth in $H_2$ could be compared with known values of the electron impact ionization rate in crossed fields. For the other gases, it is shown that under certain experimental conditions, ionization by positive ions can be important. (auth) (UK)

**20908** MEASUREMENTS ON LOW IONIZED AIR CONDUCTIVITY AND PERMITTIVITY IN MAGNETIC FIELD. Gherbanovschi, N. (Lab. of Electricity, Bucharest). Rev. Roum. Phys., 13: 905-9(1968).

The conductivity and permittivity variation of a low ionized air in the accelerating grid–anode region of a discharge tube with hot cathode, depending on a uniform external magnetic field, axially placed with the tube, were measured using a resonance method. The electric field from the grid–anode region was cancelled by the connection of a microammeter between the anode and the accelerating grid. (M.O.W.)

**20909** SOME EXPERIMENTS ON THE SPOKE PHENOMENON IN MPD OPERATION. Maisenhaelder, F.; Ungerer, E.; Kruelle, G. (Institut fuer Plasmadynamik, Stuttgart). AIAA (Amer. Inst. Aeronaut. Astronaut.) J., 7: 348-50(Feb. 1969).

A standard MPD device was used for investigating the current spoke. Segmented electrodes and image converter records were used in the analysis. Measurements are presented of the spoke current. (M.O.W.)

**20910** CHARACTERISTICS OF ELECTRODELESS DISCHARGE IN XENON. Gruzdev, V. A. Teplofiz. Vys. Temp., 6: 921-2(Sept.-Oct. 1968). (In Russian).

The discharge was started in a quartz cylinder 55 mm in diameter with side walls cooled by water at xenon pressures of $0.5 \times 10^5$ to $10^6$ $n/m^2$, and oscillation frequency of about $10^7$ cycles/sec. The inductor with three loops was 95 mm in diameter and 60 mm high. The adsorption of radiant energy by the 6 mm thickness of the water jacket could be neglected. The radiant energy flux was determined by a thermal pile. The radiant heat flux was found to be a linear function of the power in the discharge. A sharp drop in radiant energy flux determined by the pressure is observed at low discharge power. The loss of stability at low discharge power is due to the presence of local currents, as confirmed by measurements of the magnetic field by a high-frequency magnetic probe. Discharge in the volume precedes the electrodeless, induction discharge. The higher the pressure, the greater the current in the inductor necessary to obtain electrodeless discharge. The inductor current is estimated at 40 to 100 amps. (TTT)

**20911** COMPARISON OF FREQUENCY AND CURRENT MODULATION METHODS OF OBSERVING THE INTERNAL RESONANCES IN A PLASMA COLUMN. Burkley, C. J.; Sexton, M. C. (University Coll., Cork, Ireland). Int. J. Electron., 25: 125-32(Aug. 1968).

A new technique of monitoring the resonance spectrum of a dc plasma column irradiated by variable-frequency microwave energy is described. A simultaneous comparison with the conventional variable current-fixed frequency method showed clearly that parameters such as current-modulation amplitude, frequency, and in particular, the choice of increasing or decreasing sections of the current modulation cycle may have a significant effect on locating the resonances. Results are presented for argon, krypton, xenon and mercury plasmas. (auth) (UK)

## *Kinetics (Theoretical)*

*Refer also to abstract 20562.*

**20912** (CEA-CONF-1128) CONTRIBUTION OF ANALOG CALCULATION TO THE STUDY OF THE WAVE–PARTICLE INTERACTION IN HIGH-FREQUENCY PLASMA STRUCTURE. Collet, R.; Ichtchenko, G.; List, D. ([Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires]). [1968]. 27p. (In French). (CONF-680941-3). Dep.

From International Symposium on Analogue and Hybrid Computation Applied to Nuclear Energy, Versailles, France.

In order to define the energy exchanges between the high-frequency source and the particles in plasma accelerators at Saclay, the dynamics of the charged particles was studied in a system of high-frequency electromagnetic fields and nonuniform static magnetic fields. There are high coupling zones between the wave and the particles when the gyration frequency of the electrons (or the ions) is close to the frequency of the wave. Significant energy transfer results. The selection of the analog calculation is motivated by the purpose of the study (tracing of trajectories and study of the evolution of magnitudes connected with the particle) and by the properties of the differential system obtained. A formulation as simple as possible of the plasma acceleration phenomenon is proposed, eliminating the parameters whose influence can be neglected in the conditions studied. A solution type characterizing the resonance phenomenon, which facilitates an analytical approach of the solution, is sought. (tr-auth)

**20913** (N-68-36317) TRANSPORT EQUATIONS FOR GASES AND PLASMAS OBTAINED BY THE 13-MOMENT METHOD: A SUMMARY. Harstad, K. G. (Jet Propulsion Lab., Pasadena, Calif.). Oct. 1, 1968. Contract NAS-7-100. 16p. (NASA-CR-97148; JPL-TR-32-1318). CFSTI.

A summary of results obtained from 13-moment solutions to the Boltzman equations for a gas mixture is presented. The simplifications that can be achieved when one of the components has a small mass are discussed. A calculation of electron–atom collision parameters for noble gas atoms with Ramsauer cross sections (Ar, Kr, Xe) is also given. (auth) (STAR)

**20914** STUDY OF THE STRUCTURE OF SWITCH-ON IONIZING SHOCK WAVES. Tendys, John (Goddard Space Flight Center, Greenbelt, Md.). Plasma Phys., 11: 223-35(Mar. 1969).

A study has been carried out of the structure of switch-on ionizing shock waves, using a conductivity proportional to the degree of ionization. The Navier–Stokes equations with constant viscosity and heat conductivity coefficients were used. It was found that the condition proposed by Kulikovskii and Lyubimov on the structure of the shock could be used to choose a unique downstream state for a given upstream state which agreed with experimental results for a suitable choice of conductivity, though the results were quite sensitive to changes in the conductivity. It was found that this was equivalent to choosing the minimum shock thickness keeping the transverse magnetic field component always the same sign. In the weak shock limit, the condition that the downstream velocity was equal to the slow hydromagnetic wave speed was also found to hold. (auth) (UK)

**20915** VISCOSITY OF A COLLISIONLESS PLASMA IN A MAGNETIC FIELD. Milant'ev, V. P. (Patrice Lumumbu People's Friendship Univ., Moscow). Plasma Phys., 11: 145-7 (Feb. 1969).

A general expression is obtained for the viscous stress tensor of a collisionless plasma with anisotropic pressure, similar to that of Simon and Thompson, and identical with that of MacMahon. (UK)

**20916** EXISTENCE AND UNIQUENESS OF THE SOLUTION OF THE BOLTZMANN EQUATION FOR THE ELECTRON DISTRIBUTION FUNCTION OF A WEAKLY IONIZED GAS, HOMOGENEOUS AND EXPOSED TO THE ACTION OF AN ALTERNATING ELECTRIC FIELD WHEN THE PARTICLES ARE COMPARED TO INACTIVE HARD SPHERES. Molinet, Frederic (Institut Henri Poincare, Paris). Compt. Rend., Ser. A, B, 267: 1305-7 (Dec. 16, 1968). (In French).

The Boltzmann equation for the electron component of a weakly ionized gas was transformed into an integral equation that is resolved by successive approximations. The existence and uniqueness of the solution is demonstrated for the case where the initial distribution function, in the absence of external electric field, is of the type $e^{-\alpha v^2}(\alpha > 0)$. (tr-auth)

**20917** ON THE CURVATURE OF MAGNETIC LINES BEHIND A HYDROMAGNETIC SHOCK IN PSEUDO-STATIONARY FLOWS. Dwivedi, R. P.; Mishra, R. S. (Univ. of Allahabad, India). Bull. Cl. Sci., Acad. Roy. Belg., 54: 720-31(1968).

The curvature K of the magnetic line just behind a pseudo-stationary shock was determined, using the assumption that magnetic field and velocity vector are parallel. A similar problem was solved by Pant for stationary shock. Magnetic field and velocity vector, if codirectional in front of the shock, are also automatically codirectional behind the shock. The shock curve is defined to be the curve of intersection of the shock surface and the plane of flow. The flow in front of the shock was assumed to be uniform. (auth)

**20918** SYNCHROTRON RADIATION FROM SINGLE ELECTRONS GYRATING IN A MAGNETOACTIVE PLASMA. Fung, P. C. W. (Univ. of Montreal). Can. J. Phys., 47: 757-68(Apr. 1, 1969).

The incoherent synchrotron radiation power emitted by relativistic electrons gyrating in a cold magnetoactive plasma is rederived, correcting errors which have occurred in the past literature. One can specify the background plasma by the quantity $A = \omega_p^2/\omega_H^2$ ($\omega_p$ is the angular electron plasma frequency and $\omega_H$ is the angular electron gyrofrequency), i.e., the relative importance of the plasma frequency to the gyrofrequency. The general spectral features of synchrotron radiation from single electrons radiating in plasmas of large A ($A \gg 1$) and small A ($A \lesssim 1$) are discussed with the aid of a number of numerical examples. (auth) (Canada)

**20919** AMPLIFICATION OF SYNCHROTRON RADIATION IN A STREAM–PLASMA SYSTEM. Fung, P. C. W. (Univ. of Montreal). Plasma Phys., 11: 285-96(Apr. 1969).

Employing the Einstein-coefficients approach it is shown that synchrotron radiation can be amplified when a monoenergetic electron steam is gyrating in a helical path in the static magnetic field of a cold magnetoactive plasma. Errors appearing in recent literature concerning synchrotron radiation are pointed out. The frequency dependence of the amplification rate is discussed with the aid of some numerical examples. In the limiting case when the helical stream becomes a strictly rotating bunch, the result obtained is identical with that derived from the classical kinetic treatment. (auth) (UK)

**20920** COLLECTIVE MOTIONS IN CLASSICAL SYSTEMS. DISPERSION RELATION OF THE VLASOV EQUATION. Richter, J.; Voss, K. (Univ., Dresden). Ann. Phys. (Leipzig), 21: 303-11(1968). (In German).

Outgoing from the Vlasov equation and a modified Vlasov equation the dispersion relations $\omega = \omega(t)$ of quasi particles in dense classical systems are investigated. Based on Maxwell's equilibrium distribution all eigenvalues $\omega$ of the linearized equations have a negative imaginary part so that the corresponding quasi particles have finite lifetime. In the limit $t \to 0$ the velocity of sound is determined as criterion for the validity of the obtained dispersion relations. (auth)

**20921** FREE ENERGY OF QUANTUM PLASMAS OF LOW DENSITY. Ebeling, W. (Univ., Rostock, Ger.). Ann. Phys. (Leipzig), 21: 315-17(1968). (In German).

A general explicit formula for the free energy of low-density plasmas at temperatures in the range of $10^3 \lesssim T \lesssim 10^{5}$K is proposed. This formula is obtained by an analytical interpolation between the result for the free energy of low-temperature plasmas and that for high-temperature plasmas, which are known from other papers. (auth)

**20922** BINARY SLATER SUMS AND DISTRIBUTION FUNCTIONS FOR QUANTUM-STATISTICAL SYSTEMS WITH COULOMB INTERACTIONS. I. Ebeling, W.; Kelbg, G.; Rohde, K. (Univ., Rostock, Ger.). Ann. Phys. (Leipzig), 21: 235-43(1968). (In German).

High-temperature plasmas are investigated on the basis of quantum statistics. The binary distribution functions for the pairs nucleus–electron, electron–electron and nucleus–nucleus are expressed in a first approximation by the binary Slater sums. The binary Slater sums of the above mentioned pairs are expanded in a Taylor series with respect to the distance of the particles r. The value of the binary Slater sums at r = 0 as well as the first six derivatives are calculated. Effects of symmetry are taken into account. (auth)

**20923** WAVE PROPAGATION AND OTHER SPECTRAL PROBLEMS IN KINETIC THEORY. Sirovich, Lawrence (Brown Univ., Providence); Thurber, James K. J. Math. Phys. (N. Y.), 10: 239-49(Feb. 1969).

A rigorous discussion of the spectrum of the linear Boltzmann equation and kinetic models is presented. Particular attention is given to plane-wave propagation for a general class of kinetic models. These models in general have a velocity-dependent collision frequency $\nu(\xi)$. The main results of this paper concern the relationship between the complex wavenumber and complex frequency for a plane wave. It is shown that the question of analyticity of this relation is reduced to considering $\nu$ in the neighborhood of infinity. Specifically, if $\lim \nu/\xi = 0$, the relationship is not analytic. Otherwise, analyticity is obtained. (Although not specifically considered here, analyticity is closely connected to the convergence of the Chapman–Enskog procedure.) In a general discussion it is shown how the question of analyticity is closely connected with (i) the continuous spectrum of the underlying operator, (ii) the behavior of solutions at large distances from boundaries, and (iii) the nature of the cutoff in an intermolecular interaction. (auth)

**20924** USE OF GEOMETRICAL OPTICS APPROXIMATION IN ELECTRODYNAMICS OF INHOMOGENEOUS ANISOTROPIC

MEDIA. Zaitsev, Yu. A.; Kravtsov, Yu. A.; Yashin, Yu. Ya. Izv. Vyssh. Ucheb. Zaved., Radiofiz., 11: 1802-11(1968). (In Russian).

The geometrical-optics solution of Maxwell equations is derived for monochromatic normal waves in a nonabsorbing anisotropic medium when the polarization degeneration is absent. Attention is paid to the fact that in this case there exists the only (complex) condition of coincidence of the equations of the first approximation from which the equation of the energy flux density conservation is derived, as well as the equation for the wave phase. In an anisotropic dielectric, the wave phase is shown not to be changed. A simple expression for the phase is obtained for the case of high-frequency wave propagation in a magnetoactive plasma. The relation between this phase and the rotation angle of the polarization plane is established. The case of a weakly absorbing anisotropic medium is also considered. (auth)

**20925** ENERGY LOSSES OF A CHARGED PARTICLE IN A WEAK NONLINEAR PLASMA. Giorgadze, N. P.; Lominadze, D. G. (Inst. of Physics, Tbilisi, USSR). Izv. Vyssh. Ucheb. Zaved., Radiofiz., 11: 1890-7(1968). (In Russian).

The influence of nonlinear effects on the energy losses of clusters or small clouds of charged particles traversing an unbounded isotropic plasma was studied. A weak nonlinearity of plasma is displayed in the interaction of the fields of a linear approximation generated by a particle. Partial contributions of all possible processes of nonlinear interactions between waves and fields generated by the particle are determined. It is shown that the more essential correction to the polarization losses of the linear approximation is due to a nonlinear longitudinal field arising from the interaction of two longitudinal waves of the linear approximation. (auth)

**20926** ASYMPTOTIC SOLUTION OF THE FOKKER-PLANCK EQUATION AT LOW COLLISION FREQUENCY. Bhadra, Dilip K. (Gulf General Atomic Inc., San Diego, Calif.). Plasma Phys., 11: 247-58(Apr. 1969).

An asymptotic solution has been obtained for the case of low-collision frequency using a Fokker–Planck collision operator suitable for the study of the effect of electron–ion collisions on the "universal" instability in an inhomogeneous plasma. The solution, obtained under certain approximations, contains fractional powers of the collision-rate coefficient and this eliminates the divergence occurring in the expression for physical quantities like perturbed density when obtained by using a direct iterative method. An approximate study of the solutions over various ranges of the velocity variable is included. (auth) (UK)

**20927** TRANSPORT COEFFICIENTS OF PARTIALLY IONIZED KRYPTON AND XENON. Devoto, R. S. (Stanford Univ., Calif.). AIAA (Amer. Inst. Aeronaut. Astronaut.) J., 7: 199-204(Feb. 1969).

Transport coefficients of partially ionized krypton and xenon have been computed for pressures of 0.01, 0.1, 1, and 10 atm and for temperatures from 5000 to 25,000°K. Estimates are made of the probable accuracy of the results. Only very limited comparison with experimental measurements is possible, and further experiments desirable for improving and checking the accuracy of these results are suggested. (auth)

**20928** ON THE KINETIC THEORY OF STABLE AND WEAKLY UNSTABLE PLASMA. PART 2. Rogister, A.; Oberman, C. (Princeton Univ., N. J.). J. Plasma Phys., 3: 119-47(Feb. 1969).

In plasma where collective motions are made possible by the long range of the Coulomb interaction there is properly no general kinetic equation for the one-particle distribution function along. In part 1, the foundations of an enlarged kinetic theory of plasma were given, where the time evolution of the electric field fluctuations $I_k$ was considered simultaneously with the time evolution of the one-particle distribution F. These equations are now improved in a systematic fashion to include all processes which are relevant in stable and weakly unstable plasma. More precisely, the equation for the waves now includes, besides Landau damping and Cherenkov emission, the effect of collisional damping and nonlinear Landau damping, as well as emission via particle–particle scattering (bremsstrahlung), wave–particle and wave–wave scattering. The particle kinetic equation is also improved accordingly so that a kinetic description is obtained which is uniformly valid for all plasma régimes, if strong turbulence (for which there is at present no completely satisfactory statistical theory) is included. (auth) (UK)

**20929** A MODIFIED TRUNCATION PROCEDURE FOR THE BBGKY HIERARCHY. Myerscough, C. J. (Univ. of Cambridge, Eng.). J. Plasma Phys., 3: 107-18(Feb. 1969).

The approximations usually made to truncate the BBGKY hierarchy for a plasma are discussed; their failure at small interparticle separations leads to divergence of the Balescu–Lenard collision integral. A number of authors, however, have obtained convergent kinetic equations, often by rather complicated methods. It is shown that, if the standard truncation procedure is modified in a way which makes it less obviously inconsistent for close approaches, the standard methods may be closely followed in deriving a convergent collision integral which agrees to dominant order with the "cutoff" Balescu–Lenard integral and with other work on the problem. The kinetic equation obtained is identical with the Balescu–Lenard equation except that the Coulomb potential is replaced by another that is nonsingular at the origin. A physical interpretation of this result is suggested. (auth)

## Production

*Refer also to abstract 20887.*

**20930** (SC-RR-69-51) AN EXPLOSIVE GENERATOR POWERED $\theta$-PINCH. Damerow, R. A.; Crawford, J. C. (Sandia Lab., Albuquerque, N. Mex.); Fowler, C. M.; Caird, R. S.; Ewing, K. J.; Garn, W. B.; Thomson, D. B. (Los Alamos Scientific Lab., N. Mex.). Feb. 1969. 22p. Dep. CFSTI.

Explosively driven generators have been used to create neutron-producing plasma in conventional $\theta$-pinch coils. The generators are two sizes of spiral-wound flux compression devices, loaded respectively with 5 and 17 pounds of high explosive, and are used with an exploding-wire high-voltage switch to produce $\theta$ currents of approximately 2.5 and 5 megamperes, respectively. In the experiments, the rise times varied from 1.6 to 4 $\mu$sec, and the $\theta$-pinch coils were of lengths 25 and 35 cm. These currents produced fields from 106 to 224 kG in the $\theta$ coils. Five plasma shots were fired with the 2.5-megampere generator and four with the 5-megampere generator, each using a 40-kiloampere linear discharge preionizer, reverse fields of 1.7 to 3.5 kG, and 80 to 90 $\mu$ of deuterium in a preconditioned discharge tube. The highest neutron yields obtained were $7 \times 10^5$ for the 2.5-megampere case, and $1.4 \times 10^6$ for the 5-megampere generator. On the highest-yield shots, the peak neutron yield rates per unit coil length compared favorably with those obtained in the largest known laboratory $\theta$ pinches. The yield rate dropped to a low value well before peak field in all cases, suggesting typical short coil losses. The results also indicate that efficient high-voltage switching is a key to good neutron production. (auth)

**20931** LASER APPLICATION FOR INVESTIGATIONS OF THE HIGH-TEMPERATURE AND PLASMA PHENOMENA. Basov, Nikolai G.; Krokhin, Oleg N.; Sklizkov, Gleb V. (Lebedev Inst. of Physics, Moscow). IEEE (Inst. Elec. Electron. Eng.), J. Quant. Electron., QE-4: 988-91(Dec. 1968).

The wide power dispersion and high effective temperature of radiation call forth the useful application of lasers for the investigation of high-temperature and gas dynamical processes as well as in plasma physics. By means of lasers, it is possible to investigate the phase transition in any substance, determine the thermophysical parameters, and study the phase transition kinetics in the wide interval of temperature and pressure. It is also possible to study the state equation and optical properties of various substances at high temperatures. The powerful lasers permit production of high-temperature plasmas of any chemical composition and the strong shock wave in the gases and dense media. The maximum obtained velocities reach up to 300 km/s and temperatures more than 100 eV. The described plasma is an interesting object for study of various elementary processes taking place in the equilibrium as well as in the nonequilibrium state of the substance. (auth)

**20932** DEVICE FOR THE PRODUCTION AND CONFINEMENT OF IONIZED GASES. Consoli, Terenzio; Dupas, Lucien; Leroy, Jean (to Commissariat a l'Energie Atomique). U. S. Patent 3,425,902. Feb. 4, 1969. Priority date Mar. 11, 1966, France.

A method of production and confinement of an ionized gas wherein a nonionized ionizable gas is passed into a chamber at one end of a discharge space in which the gas thus introduced is subjected to a magnetic field having a continuous axial component as well as a radial component having a minimum value in at least a central region and to a circularly polarized high-frequency wave higher than $10^9$, and a device for the application of said method. (auth)

**20933** PLASMA PRODUCTION IN A DISCHARGE PINNED TO A WALL BY A MAGNETIC FIELD. Gorshkova, L. D.; Gorshkov, V. A.; Podmoshenskii, I. V. Teplofiz. Vys. Temp., 6: 1130-2(Nov.-Dec. 1968). (In Russian).

Experiments with capillary discharge to a wall which is to be volatilized show that the amount of required power is on the order of $10^5$ to $10^6$ watts/cm$^2$ in order to attain instantaneous evapora-

tion irrespective of the material of construction (organic polymer or refractory materials such as $SiO_2$, MgO and SiC). The corresponding rate of evaporation should be 1 to 10 cm/sec. High temperature and pressure are obtained under conditions of a powerful discharge which is directed to the bottom wall of a boat by a magnetic field which is created by means of a toroidal coil through which a battery of condensers was discharged to give a field strength of $H = 1.2 \times 10^6$ amps/m. Two symmetrical streams of materials flowed out through the open ends of the boat. The discharge current was found to be $7 \times 10^3$ amps by oscillographic measurement. The channel cross-section was about 1 $cm^2$. The drop in potential was 350 volts. The plasma temperature was about 15,000°K. The excess pressure at the bottom of the boat was $8 \times 10^5$ $n/m^2$. The power in the discharge was $2 \times 10^6$ watts with an evaporation rate of 13 mm/sec. In this process no selectivity in evaporated constituents was noted. This type of discharge can find use in studying plasma properties, in introducing surface coatings, and in spectral practice. (TTT)

## Stability

*Refer also to abstract 21190.*

**20934** (N-68-36689) STABILITY OF A PURE ELECTRON PLASMA IN CYLINDRICAL GEOMETRY. Progress Report. Knorr, Georg (State Univ. of Iowa, Iowa City. Dept. of Physics and Astronomy). Aug. 1968. Contract Nonr-1509(06). 27p. (NASA-CR-97189). CFSTI.

The stability of a cylindrical cold plasma consisting of electrons only is investigated analytically. The geometry is similar to that of the proposed heavy ion plasma accelerator. The dispersion equation is derived and discussed for the case that the plasma rotates like a rigid body. The resulting instabilities are found to be much more violent than those studied by Buneman et al. for a straight geometry. The underlying physics is discussed. (auth) (STAR)

**20935** (ORO-3405-25) INVESTIGATION OF UNIVERSAL PLASMA INSTABILITIES. Quarterly Report No. 10, June 1, 1968-August 31, 1968. (Maryland Univ., College Park. Inst. for Fluid Dynamics and Applied Mathematics). Contract AT-(40-1)-3405. 9p. Dep. CFSTI.

A brief review of research carried out during this period is given on ion acoustic waves and periodic pulling and turbulence in Q devices. (M.O.W.)

**20936** (ORO-3405-26) INVESTIGATION OF UNIVERSAL PLASMA INSTABILITIES. Quarterly Report No. 11, September 1, 1968-November 30, 1968. (Maryland Univ., College Park. Inst. for Fluid Dynamics and Applied Mathematics). Contract AT(40-1)-3405. 13p. Dep. CFSTI.

A brief summary of research on drift waves and active Fabry-Perot microwave resonators is presented. The drift-wave studies were made in a single-ended Q machine filled with potassium. (M.O.W.)

**20937** (UCRL-18751) QUASILINEAR EVOLUTION OF THE TRANSVERSE INSTABILITY DRIVEN BY TEMPERATURE ANISOTROPY OF AN UNMAGNETIZED PLASMA. Albright, Norman Webster (California Univ., Berkeley. Lawrence Radiation Lab.). Jan. 28, 1969. Contract W-7405-eng-48. 135p. Dep. CFSTI.

Thesis.

Starting with a temperature anisotropic plasma, a spectrum of purely growing magnetic waves develops in k-space. These waves cause particle diffusion in velocity space. This leads to temperature isotropy and thus to stabilization of the plasma. After a brief period of rapid diffusion, the anisotropy decreases with time like $t^{-\frac{1}{2}}$. Simultaneously the wave spectrum shifts to lower and lower wave numbers, and eventually decays. (auth)

**20938** ROTATING PLASMA AND GRAVITATIONAL INSTABILITY. Barbian, E. P.; Rasmussen, C. E. (FOM Inst. for Atomic and Molecular Physics, Amsterdam). Plasma Phys., 11: 197-209(Mar. 1969).

A rotating plasma discharge produced with an independent electric field applied transverse to the magnetic field, shows an $m = 1$ instability during the buildup phase. The growth rate of a high-mode instability (m-number between 5 and 15) which occurs during the main phase of the discharge is measured in dependence on the local centrifugal acceleration. The results can be compared with the theory for the gravitational modes by Chen. The influence of the Coriolis force and of finite Larmor radius effects on the growth rate is discussed. A general survey of the development of the discharge is also given. (auth) (UK)

**20939** STABILIZATION OF A DYNAMIC MODE OF A WEAKLY IONIZED PLASMA BY LARGE ELECTRON DRIFTS. Milic, B. (Inst. of Physics, Belgrade). Fizika (Zagreb), 1: 59-68(1968).

Three slow and shortwave aperiodic modes with phase velocities and wavelengths smaller than electron thermal velocity and mean-free-path, respectively, and with the electric vector of the wave lying in the $(\vec{k}, \vec{E}_0)$-plane are considered in a homogeneous and infinite weakly ionized and nonmagnetized plasma placed in a strong external electric dc field $\vec{E}_0$. Waves propagating at right angles to $\vec{E}_0$ are studied. Modal spectra are determined from kinetic theory using an extended Margenau-Davydov electron steady-state distribution function. It is shown that, under broad assumptions regarding e-n elastic scattering, two finite critical values of electron drift can be specified for one of these modes. If electron drifts lie in this critical range, increasing amplitude waves corresponding to this mode appear; on the contrary, large electron drifts have a stabilizing effect. (auth)

**20940** OBSERVATION OF VELOCITY-SPACE INSTABILITY. Morse, D. L. (United Kingdom Atomic Energy Authority, Abingdon, Eng.). Plasma Phys., 11: 175-82(Mar. 1969).

A column of plasma is generated in which electrons have a large fraction of their total energy associated with the velocity components transverse to an applied axial magnetic field. An unstable wave is found to arise spontaneously which propagates along the axis of the column. The properties of the plasma column and the dispersion characteristics of the unstable wave are studied and compared with the theory of Gruber et al. (1965). (auth) (UK)

**20941** WARM PLASMA STABILIZATION OF THE CONVECTIVE LOSS CONE MODE. Moir, R. W. (EURATOM-CEA, Fontenay-aux-Roses, France). Plasma Phys., 11: 169-74(Mar. 1969).

It is found that the addition of a small quantity of warm plasma to a mirror-confined hot plasma stabilizes the high-density convective loss cone mode. For example, with a well-randomized distribution appropriate to a mirror ratio of 10 and with low electron temperature, the relative warm plasma density needed is 2.7% and its relative energy is 6.3%. (auth) (UK)

**20942** TEMPERATURE STABILITY OF A SLIGHTLY IONIZED GAS FOR ARBITRARY COLLISION CROSS SECTIONS. Vogel, R. W. (Univ. of S. Florida, Tampa). Plasma Phys., 11: 163-8(Mar. 1969).

A simple model is used to discuss the electron temperature variation in an infinite media as the electric field strength varies. A temperature equation with a temperature dependent collision frequency is obtained. Limiting cases are investigated, and the temperature stability is investigated. Stability criteria are developed. (auth)

**20943** EFFECT OF RADIANT EMISSION AND OF THERMAL CONDUCTIVITY ON THE CONDITIONS OF DEVELOPING IONIZATION INSTABILITY. Gruzdeva, V. F.; Lagar'kov, A. N. Teplofiz. Vys. Temp., 6: 923-4(Sept.-Oct. 1968). (In Russian).

A set of equations is written where dissipative losses due to radiant emission in the discrete spectrum and due to thermal conductivity are taken into account in the energy balance equation for electrons. In addition, equations are added for the concentrations of excited atoms with finite relaxation time and equilibrium concentration of the excited atoms being taken into account. A study on the stability of this system leads to a dispersion relation for oscillations which propagate in a plane perpendicular to the magnetic field. Consideration of two limiting cases shows that the role of radiant emission and thermal conductivity reduces to an energy jump from the hot region to the cold region. Estimates show that thermal conductivity can be neglected in comparison with radiant emission except at very small wavelengths. It is also shown that radiant emission is a stabilizing factor which hinders the development of ionization instability. The results were obtained on the assumption of an unlimited volume. With a decrease in volume the effect of radiant emission should apparently decrease. (TTT)

**20944** PLASMA STABILIZATION BY ROTATION OF ARC DISCHARGE TUBE. Simon, Donald R.; Rogers, Kenneth C.; Sileo, Francis R. (to Vitro Corp. of America). U. S. Patent 3,426,233. Feb. 4, 1969. Filed Dec. 13, 1965.

A gaseous medium with an initial density of at least 0.02 kilogram/$meter^3$ is pre-ionized to yield an electron density of at least $10^{16}$ electrons/cc. by the passage through the medium of an electric arc which is positionally stabilized by rotating the enclosure for the medium to rotate the medium. The pre-ionized medium is caused to emit soft x rays and/or short ultraviolet by compression thereof by a transient axial magnetic field generated by a theta coil. The yield of radiation may be enhanced by the use of a supplemental dc axial magnetic field opposing the transient field. (Offic. Gaz.)

**20945** CENTRIFUGAL INSTABILITY IN AN RF PLASMA. Wort, D. J. H. (United Kingdom Atomic Energy Authority, Abingdon, Eng.). Plasma Phys., 11: 357-8(Apr. 1969).

Plasma instabilities in the "Helios" device were investigated, using Langmuir and electrostatic probes, and it is concluded that these low-frequency instabilities are adequately described by Chen's theory for centrifugal instabilities. (UK)

## *Thermonuclear Processes*

**20946** (CEA-CONF-1003) STELLARATOR-TYPE CONFIGURATIONS WITH MEDIUM WELLS AND SHEARING OF MAGNETIC LINES. Gourdon, C.; Marty, D.; Maschke, E. K. (Commissariat a l'Energie Atomique, Fontenay-aux-Roses (France). Centre d'Etudes Nucleaires); Dumont, J. P. (Societe d'Etudes Techniques et d'Entreprises Generales, Le Plessis-Robinson (France)). [1968]. 15p. (In French). (CN-24/F-2; CONF-680805-28). Dep.

From 3rd International Conference on Controlled and Plasma Physics, Novosibirsk, USSR.

Recent theoretical studies on toroidal magnetic configurations of the stellarator type have shown a serious limitation of the maximum rotational transformation angle. A systematic study was made of those configurations proposed that permit simultaneously a median magnetic well and a shearing of the lines of force. A complete analysis of the configurations of different multipolar orders made it possible to distinguish a new class of configurations called "torsatron." A study was made of the effect of perturbations on the magnetic surfaces. The individual confinement of the particles was also considered. The study was done by numerical integration of the magnetic lines and the particle trajectories. The magnetic field was calculated from the conductor data. (J.S.R.)

**20947** (EUR-4197) ON THE GENERATION OF HIGH-MAGNETIC FIELDS (MEGAGAUSS) BY CYLINDRICAL IMPLOSION. Somon, J.-P. (Comitato Nazionale per l'Energia Nucleare, Frascati (Italy). Laboratorio Gas Ionizzati). Dec. 1968. 98p. (In French). Dep.

This work is a theoretical study of the generation of high magnetic fields by the explosive-driven cylindrical implosion of a hollow conducting cylinder against a trapped axial field. Several mechanisms are limiting the efficiency of the process and are successively considered: energy losses due to the conductor compressibility, magnetic flux losses by field diffusion, conductor destruction by Rayleigh-Taylor instability of motion or by vaporization due to Joule heating. These phenomena are studied and criteria for maximum fields are derived. It may be concluded that the implosive generation of fields around 20 MG seems to be possible; it should be extremely difficult to achieve greater fields. The main experiments are described and their results compared to the theory. (auth)

**20948** (UCRL-71539) NEW ASTRON ACCELERATOR AND MAIN CHAMBER. Hurley, Charles A. (California Univ., Livermore. Lawrence Radiation Lab.). Mar. 21, 1969 12p. (CONF-690407-1). Dep. CFSTI.

From Symposium on Engineering Problems of Fusion Research, Los Alamos, N. Mex.

Astron has gone through a remodeling period in which the main trapping chamber and the linear-induction electron accelerator were completely redesigned. Greater operating reliability combined with mechanical flexibility and accuracy were the desirable qualities included in the design criteria of the main trapping chamber. This chamber consists of an aluminum vacuum chamber approximately 90 ft long 63 in. o.d., with 4-in.-thick water-cooled walls, supports an infinite solenoid coil system of 1100 gauss at the center, and accommodates 250 diagnostic port penetrations. The inside diameter of the chamber is lined with resistors made of 0.0015-in. tungsten wire. The chamber can be aligned to within 0.040-in. in length and can be moved by floating on a thin film of air. The primary electronic requirements for the new accelerator were to increase the current output from 400 to 1000 amp, to include additional space for the diagnostics and monitoring, and to increase the energy above 4 MeV. The physical design features of the accelerator consist of an increasing gradient gun followed by four constant-gradient 8-in.-bore injector sections. Fifteen identical, 20-core units, each with a 4-in. aperture, make up the remainder of the accelerator. Between these units is space for beam diagnostics, focusing, and steering. (auth)

**20949** PERFORMANCE STUDIES OF PLASMA ACCELERATORS. Friedel, H.; Lackner, K. (Univ., Innsbruck). pp 261-71 of Problems of Propulsion and Re-entry. Lunc, Michal (ed.). New York, Gordon and Breach, Inc., 1967.

From 17th International Astronautical congress, Madrid. See CONF661051.

Numerical calculations were made for evaluating the performance of Faraday and traveling-wave accelerators. One-dimensional analyses were made for both accelerators. (M.O.W.)

**20950** DYNAMICS AND NEUTRON EMISSION OF A FOCUSED NONCYLINDRICAL ELECTRIC DISCHARGE. Patou, C.; Simonnet, A.; Watteau, J. P. (Commissariat a l'Energie Atomique, [Paris]). J. Phys. (Paris), 29: 973-84(Nov.-Dec. 1968). (In French).

The dynamics of an electrical discharge produced between two coaxial cylindrical electrodes or "plasma focus" is reported. The axial propagation of the discharge along the electrodes followed by the radial compression in front of the inner electrode are interpreted using the one- and two-dimension snow plow models. The energy transferred to the plasma during the radial compression is experimentally uncontrollable, but this energy and the neutron yield seem to be correlated. A precise chronology of the radial compression determines the neutron emission time with respect to the discharge dynamics; in particular, this emission starts when the luminous front of the discharge is still 1 cm away from the axis of the electrodes. (auth)

**20951** GENERATION OF LONG-DURATION AND HIGH-VELOCITY PLASMA FLOW IN A MULTI-SEGMENTED PLASMA TUBE BY THE GAS INJECTION METHOD. Kim, Chick-hyun (Seoul National Univ.). J. Korean Phys. Soc., 1: 67-80(Oct. 1968).

In order to generate a uniform plasma flow having long duration, Fowler's multi-segmented plasma tube has been improved upon in the following two points: (1) a "gas-inject method" is adopted, i.e., a discharge is induced at the instant the testing gas is injected from the outside into the highly evacuated tube; and (2) a discharge order in the "down-to-up stream direction" is adopted for the main discharge. As a result of this study, it is verified that these improvements make possible the effective transfer of the electric energy to the kinetic energy of the gas to extend the duration of plasma flow. (auth)

**20952** PHYSICS OF ELECTRIC PROPULSION. Jahn, Robert G. McGraw-Hill Series in Missile and Space Technology. New York, McGraw-Hill Book Company, 1968. 356p. $14.50.

The concepts of electric acceleration of gases for propulsion are developed, starting from primary physical principles and culminating in realistic space thruster designs. The basics of electric propulsion are reviewed, and then the various methods are discussed in some detail. (M.O.W.)

**20953** IMPROVEMENTS IN OR RELATING TO COLD CATHODE, GLOW DISCHARGE DEVICES. Dugdale, Ronald Arthur (to United Kingdom Atomic Energy Authority). British Patent 1,145,013. Mar. 12, 1969. Filed Mar. 19, 1965.

A nonthermionic cathode glow discharge device is described which comprises an enclosure with gas inlet and outlet means; an electrode arrangement is mounted within the enclosure, the electrode arrangement including a tubular anode open at both ends and a cathode adjacent to one end of the anode. On applying electrical potential a glow discharge occurs, and at least some of the positive ions created in the gas bombard the cathode, causing it to emit a stream of electrons which are focused and directed axially with respect to the anode by the electric fields associated with the anode and cathode. The cathode may be planar except for a central well, the bottom of the well being planar and parallel to the general plane of the cathode. The electrode arrangement may include a biasing electrode adjacent to the side of the cathode remote from the anode. The cathode may be provided with a central circular aperture symmetrically disposed relative to the anode. Other more complex electrode assemblies are also described. The cathode may also be formed by the end of a rod disposed on the axis of the anode and projecting through an aperture in the biasing electrode. Means are provided external to the electrode arrangement to focus or deflect the stream of electrons. (UK)

**20954** A SIMPLE MODEL OF THE COAXIAL PLASMA GUN WITH POSITIVE CENTRAL ELECTRODE. II. Pert, G. J. (Univ. of Alberta, Edmonton). J. Phys., D (London), 2: 429-34 (Mar. 1969).

The model of the coaxial plasma gun presented in Part I of this paper has been extended by consideration of the detailed structure of the flowing gas layer preceding the driving current sheet. It is found that to a good degree of approximation the gas is uniform across the layer. The conservation of energy equation then reduces to Bernoulli's equation, and allows calculation of the state of the gas in the layer. The range of validity of the model is examined. (auth) (UK)

## Wave Phenomena

**20955** (CEA-CONF-1064) EXPERIMENTAL STUDY OF THE WAVE-PARTICLE INTERACTION IN A PLASMA PRESENTING A "DOUBLE-HUMP" DISTRIBUTION FUNCTION. Frank, R. Nov. 3, 1968. 15p. (In French). (CONF-680830-2). Dep.

From International Symposium on One Particle Distribution Functions in Plasmas, Marburg, Germany.

A detailed experimental study was made of the mechanism of energy exchange between the plasma oscillations and the electrons in a plasma having a double-hump distribution function. The experimental installation is briefly described and then the results are reported. These show that, in the relaxation regime, a plasma characterized by a distribution function verifying the conditions required by the application of the quasi-linear theory was obtained. Deformation of the distribution function and growth of the waves were studied in detail in order to establish the energy exchange mechanism between the waves and the particles. Comparison between this mechanism and that deduced from the quasi-linear theory leads to the conclusion that the model described by this theory is valid. In particular, the rate of growth of the waves is in good agreement with the theoretical growth rate deduced from the slope of the distribution function and the spectrum of the oscillations is well fixed by the length of the final plateau and not by the coupling of modes. In the stationary regime, on the contrary, the distribution function is close to that describing the interaction of a semi-infinite plasma with a cold beam injected at its border. It was shown that the instability resulting from the interaction between the fast electron beam and the plasma is convective, i.e., the oscillations are excited in the vicinity of the border between the tube and the plasma and are developed on a determined distance. Along the distance where the waves grow, the fast electron hump is deformed and disappears. This is expressed by a deformation of the distribution function analogous to that observed in the relaxation regime. The energy exchange mechanism between the waves and the particles, in a strongly nonlinear case, remains qualitatively similar to that described by the quasi-linear theory. (tr-auth)

**20956** (NP-17813) MAGNETO-ACOUSTIC OSCILLATION OF A PLASMA CYLINDER: NORMAL MODE ANALYSIS UP TO SECOND ORDER. Schuurman, W. (Stichting voor Fundamenteel Onderzoek der Materie, Jutphaas (Netherlands). Instituut voor Plasma-Fysica). Nov. 1968. 18p. Dep.

A theory is presented of radial magneto-acoustic oscillations of a plasma cylinder surrounded by vacuum, following a linearization procedure of MHD-equations, with second order included. Comparison with a numerical example taken from a Rijnhuizen screw pinch shows qualitative agreement. (auth)

**20957** (UCRL-18678) TURBULENCE IN THE POSITIVE COLUMN OF A GLOW DISCHARGE. Halseth, Martin W. (California Univ., Berkeley. Lawrence Radiation Lab.). Feb. 1969. Contract W-7405-eng-48. 113p. Dep. CFSTI.

Thesis.

The helical instability, which first appears in the positive column of a glow discharge at a critical magnetic field, $B_c$, is found to be replaced by random oscillations when the magnetic field is greater than 15 times the critical field. Measurement of the correlation of the ion density at two points along a tube diameter shows that the oscillations are out of phase with each other by more than 90 deg when the points are on opposite sides of the tube and the field is less than 15 times $B_c$, indicating that a helical oscillation is present. When $B/B_c$ is greater than 15, the correlation decays exponentially with radial separation of the two points and remains positive, or nearly so, as in a turbulent plasma. The radial exponential decay length, which corresponds to the turbulent mixing length, and the radial density profile show good agreement with calculations made from a theory for turbulence in the positive column, proposed by Kadomtsev. Measurements were made in He for various pressures up to 400 mTorr and magnetic fields up to 12 kilogauss. Mixing lengths were measured and found to be about 30% of the radius in the turbulent plasma at the highest magnetic fields. Frequency spectra were continuous, in agreement with the requirements for a strongly turbulent plasma, and the electric field was essentially independent of magnetic field, in agreement with the theory of Kadomtsev for a strongly turbulent plasma. Turbulent radial particle transport fluxes are independent of the value of the magnetic field, and, because of the close agreement between measured and calculated radial mixing lengths and radial density profiles, agree well with empirical values of particle production rates. At lower magnetic fields, the properties of the plasma agree with those calculated from the semi-empirical theory of Sheffield based on the theory of Holter and Johnson for a large-amplitude helix in a positive column. In the positive column for magnetic fields below 15 $B_c$ higher modes of the helical instability were temporarily produced by use of a time-dependent electric field. The frequency and electric field associated with these waves were measured. By use of the theory of Holter and Johnson and the measured electric fields, calculations of the frequencies for the higher modes were made which compared favorably with the experimental values. (auth)

**20958** ELECTRON CYCLOTRON INTERACTION IN A MAGNETIC MIRROR COMPRESSION EXPERIMENT. Tuma, David T. (Univ. of California, Irvine); Lichtenberg, Allan J.; Trivelpiece, Alvin W. Plasma Phys., 11: 117-20(Feb. 1969).

A single-stage mirror compression experiment was used to study the cyclotron resonance absorption of 3- and 8-mm-wavelength radiation injected into the plasma early in the compression phase. The results indicate that while the high-energy tail of the distribution function was altered by a few electrons that gained significant energy, the main body of the plasma electron distribution function was not significantly heated by the rf power. Based on a single-particle analysis, one was led to believe that the plasma is mainly confined to the midplane region of the magnetic mirror. (auth) (UK)

**20959** TURBULENT DENSITY FLUCTUATIONS IN ZETA. Robinson, D. C. (United Kingdom Atomic Energy Authority, Abingdon, Eng.); Rusbridge, M. G. Plasma Phys., 11: 73-100 (Feb. 1969).

Observations on the fluctuations from a double Langmuir probe are presented. It is shown that these can be interpreted in terms of fluctuations of the density, temperature, their gradients and the electric field. The measurements are consistent with the theory, and it is found that the fluctuations are adiabatic at high pressures and isothermal at low pressures. The properties of the fluctuations are compared with the predictions of a theory of hydromagnetic turbulence, which allows one to consider the origin of the observed density fluctuations. It is concluded that they arise from flow along the magnetic field lines. Measurements of correlation functions both in space and time are described and their significance in terms of a containment time and wave motion is discussed. (auth) (UK)

**20960** ATTENUATION OF ELECTROMAGNETIC SURFACE WAVES ON PLASMA COLUMNS. Anicin, B. A. (Boris Kidric Inst., Belgrade). Fizika (Zagreb), 1: 69-80(1968).

The attenuation coefficient of an electromagnetic surface wave is derived using a perturbation method which takes into account both collisional loss in the plasma and dielectric loss in the surrounding glass. The attenuation coefficient increases as the square of the phase coefficient in the region of low phase velocity. Numerical data are presented for both dipole and axially symmetric modes. The theory is compared with recent experimental observations. (auth)

**20961** PROPAGATION OF ALFVEN WAVES IN NONHOMOGENEOUS PLASMA IN THE PRESENCE OF THE HOMOGENEOUS GRAVITATIONAL FIELD. Deutsch, R. V. (Polytechnic Inst., Iasi); Fornwald, F. Rev. Roum. Phys., 13: 895-900(1968).

The propagation of Alfvèn waves in two-dimensional nonhomogeneous systems, in the presence of a homogeneous gravitational field, was studied. Alfvèn waves propagate, even in this case, along the force lines of the magnetic field. The existence of the magnetic field results, on the one hand, in the variation of the oscillation amplitude with the altitude, and on the other hand, in the distortion of the perturbation profile. (auth)

**20962** THE NONLINEAR FOCUSING OF TE WAVES IN A TWO-LEVEL SYSTEM. Demchenko, V. V. (Kharkov State Univ.). Ukr. Fiz. Zh., 13: 1923-4(Nov. 1968). (In Russian).

A waveguide channel, contained by the pressure of the electromagnetic field of the wave, may be created in a nonlinear plasma. This so-called self-focusing of electromagnetic waves was examined in a nonlinear, two-level dielectric, assuming that the frequency of the electromagnetic wave is close to one of the resonance frequencies of the plasma. Integration of the equations involving the electric field amplitude and the nonlinear dielectric permeability of the medium allowed to determine the conditions required for self-focusing. The calculations indicated that the structure of the field corresponds to those required by the formation of a waveguide channel in the medium. (TTT)

**20963** PROPAGATION OF STRONG-FIELD ELECTROMAGNETIC WAVES THROUGH PLASMAS NEAR THE ELECTRON CYCLOTRON FREQUENCY. Bachynski, M. P.; Gibbs, B. W. (Radio Corp. of America, Montreal). Phys. Rev. Lett., 22: 583-7(Mar. 24, 1969).

The effect of electric field strength of the incident wave on the transmission of electromagnetic waves through an anisotropic plasma has been investigated using field strengths of 27.4 to 137 V/m. Near the electron cyclotron frequency increased transmission occurs for the strong field strengths. (auth)

**20964** GENERATION OF SUM AND DIFFERENCE FREQUENCIES IN PLASMAS BY NONUNIFORM MICROWAVE FIELDS. Sodha, M. S.; Gupta, G. P. (Indian Inst. of Tech., New Delhi). Indian J. Pure Appl. Phys., 7: 54-60(Jan. 1969).

Starting from the Boltzmann's transfer equation, an analysis has been made of the nonlinear generation of the sum and difference frequencies in the current density in a slightly ionized plasma, arising because of the nonuniform nature of the applied microwave fields. The analysis has been extended to a homogeneous semiconductor at low temperatures taking account of the scattering of electrons due to acoustic phonons and ionized impurities. Some numerical results illustrating the effect of collisions on frequency mixing have also been given. (Indian Sci. Abstr.)

**20965** COLLECTIVE INTERACTIONS OF ELECTROMAGNETIC WAVES IN A PLASMA. Cavaliere, A. (Laboratori Gas Ionizzati, Frascati, Italy). Nuovo Cim., Suppl., 6: 925-38(1968). (In Italian).

The elementary modes and their excitation are described. The interaction of modes and the scattering of the electromagnetic wave are discussed. The transition from scattering to absorption is considered. The limits of the stimulated scattering and the abnormal absorption are derived. (J.S.R.)

**20966** DISPERSION RELATIONS FOR A COMPRESSIBLE ISOTROPIC TURBULENT PLASMA. Collin, R. E. (Case Western Reserve Univ., Cleveland). Radio Sci., 4: 279-94 (Mar. 1969).

An analysis of the propagation of the mean or average plane wave in a compressible isotropic turbulent plasma is presented. It is shown that the average wave separates into a longitudinal and a transverse mode, and their dispersion relations are derived. The analysis is based on the first-order smoothing theory in the form developed by Keller and assuming a Gaussian correlation function. It is found that mode coupling is a strong effect in the short correlation length region but becomes negligible for long correlation lengths. Useful approximations to the dispersion relations are also given for the short, intermediate, and long correlation length regions as well as numerical results for the perturbed propagation constant of the average transverse wave. The application of the theory to a random dielectric medium is pointed out and a quantitative evaluation of the importance of the depolarization term, i.e., the grad div term, in the vector Helmholtz equation is made. (auth)

**20967** TRANSIENT SIGNAL PROPAGATION THROUGH AN INHOMOGENEOUS PLASMA. Casey, Kendall F.; Case, Carl T. (Air Force Inst. of Tech., Wright-Patterson AFB, Ohio). IEEE (Inst. Elec. Electron. Eng.), Trans. Antennas Propagation, AP-17: 86-9(Jan. 1969).

The propagation of a transient electromagnetic field through a cold, isotropic, lossless, inhomogeneous plasma is considered. The electron density of the plasma decreases exponentially in the direction of propagation. For incident transient signals whose Laplace transforms are regular at infinity and whose only singularities are poles, the transient electric field propagated through the plasma can be expressed as a sum of exponential waves at discrete complex frequencies. The characteristic frequencies of the inhomogeneous plasma are related to the zeros of the modified Bessel function of the first kind of fixed argument and variable order. When the Laplace transform of the incident signal is not well-behaved at infinity, approximate methods may be used to evaluate the transient electric field. The propagations of a step sine wave and of a quasi-monochromatic Gaussian pulse are considered. It is found that for plasmas characteristic of reentry boundary layers, the effect of the plasma layer on dispersion is very small. The principal effect of the layer is to attenuate a signal propagated through it. (auth)

**20968** ENERGY DENSITY AND VELOCITY OF ENERGY TRANSPORT OF A rf WAVE IN PLASMA WHEN THE WAVE FREQUENCY APPROACHES THE FREQUENCY OF DAMPED OSCILLATIONS. PART II. Bhagavat, G. K.; Nandedkar, D. P. (Indian Inst. of Tech., Bombay). Int. J. Electron., 25: 143-51 (Aug. 1968).

The oscillatory motion of an electron in a plasma is analyzed and the conditions for maximum values of amplitude and velocity of displacement are derived. Energy associated with equivalent inductive and capacitive circuits is discussed and the conditions for resonance, as well as the position of half-energy density points, are indicated. It is shown that the velocity of energy transport at half-energy density points is twice its value at resonance. (auth) (UK)

**20969** ENERGY DENSITY AND VELOCITY OF ENERGY TRANSPORT OF A rf WAVE IN PLASMA WHEN THE WAVE FREQUENCY APPROACHES THE FREQUENCY OF DAMPED OSCILLATIONS. PART I. Bhagavat, G. K.; Nandedkar, D. P. (Indian Inst. of Tech., Bombay). Int. J. Electron., 25: 133-42(Aug. 1968).

In a previous paper (Bhagavat and Nandedkar 1968) an investigation of the damped oscillations in plasma was described. An analysis of energy density and velocity of energy transport of a wave in the region where damped oscillations were discovered is now presented. (auth) (UK)

**20970** INITIAL VALUE PROBLEM FOR A PLASMA IN AN EXTERNAL FIELD. Kuszell, A.; Senatorski, A. (Inst. of Nuclear Research, Warsaw). Acta Phys. Pol., 35: 19-32(Jan. 1969).

The longitudinal plasma oscillations in an external electric field are investigated by means of numerical solutions and an approximation technique. For weak external fields the phase integral approximation and multitime scales perturbation techniques are used. The approximate solutions in the form of damped oscillations with time-dependent frequencies are found. The mechanism of instability growth is discussed. (auth)

**20971** STUDY OF THE STABILITY AND CONDITIONS OF PROPAGATION OF LOW-FREQUENCY WAVES IN A LINEAR HARD-CORE CONFIGURATION. Adam, J.; Alvarez de Toledo, F. Rebut, P. H.; Torossian, A. (EURATOM–CEA, Fontenay-aux-Roses, France). Plasma Phys., 11: 297-319(Apr. 1969). (In French).

The results of measurements made on plasma confined in a linear hard-core configuration (EPPE) are summarized. The maximum plasma density is 1 to 2 × $10^{15}$ $cm^{-3}$, and the ion and electron temperatures reach 50 eV. When the current flowing in the plasma exceeds 80 kA large magnetic fluctuations are observed, which can be identified with the tearing modes. Investigation of the conditions for excitation of the low-frequency electromagnetic waves shows that two distinct modes can be excited, in agreement with the solution of the wave equation. Efficient damping of one of these modes has been observed. The possible origin of that damping is discussed. (auth) (UK)

**20972** THEORY OF HIGH-FREQUENCY ELECTROSTATIC WAVES IN A NONUNIFORM PLASMA IN THE PRESENCE OF A MAGNETIC FIELD. Lashmore-Davies, C. N. (United Kingdom Atomic Energy Authority, Abingdon, Eng.). Plasma Phys., 11: 271-84(Apr. 1969).

High-frequency electrostatic waves which propagate in a nonuniform plasma in the presence of a uniform magnetic field are described. The analysis is carried out in cylindrical geometry and both perfectly conducting and vacuum boundary conditions are included. Solutions of the dispersion relation corresponding to waves propagating perpendicularly (even for a uniform plasma column) and obliquely to the magnetic field are obtained. For the case of oblique propagation there are two branches to the dispersion relation for a given value of |l| where l is the azimuthal mode number. The relationship of these waves to the low frequency drift waves of a nonuniform plasma and to the lower branch of the modes discussed by Trivelpiece and Gould (1959) is considered. The attenuation of the waves due to collisions is computed. The validity of the electrostatic approximation is examined. (auth) (UK)

## Shielding

*Refer also to abstracts 19890, 21234, and 21543.*

**20973** (BMwF-FBK-68-37) HOW WELL DOES THE MONOENERGETIC TRANSPORT EQUATION APPLY TO GAMMA RAYS? Gerstl, S. A. W. (Technische Hochschule, Karlsruhe (West Germany). Institut fuer Struktur der Materie). Aug. 1968. 28p. (In German). Dep.

Starting from the space-, energy- and angular-dependent transport equation, the approximations concerning the energy dependency and the anisotropy of the scattering process, which lead to the monoenergetic transport equation with linear anisotropy, are discussed. After the discussion of the well-known analytic solutions of this monoenergetic equation by Kofink and Case, their application to gamma rays is investigated. The monoenergetic Klein–Nishina scattering kernel is expanded into a series of Legendre polynomials; exact analytic expressions are calculated for the moments of this expansion up to any order. In the approximation treatment of the scattering cross section, by taking only the first two or three terms of the expansion into account, certain "physical domains" of the expansion coefficients can be defined by mathematical criteria. The applicability of the imposed approximations is then discussed by means of numerical examples. The results show definitely that the monoenergetic transport equation represents an insufficient approximation for gamma-ray problems, not only in the case of linear anisotropic scattering, but also in the quadratic case. (auth)

**20974** (NP-17789) NEUTRON TRANSMISSION THROUGH MULTILAYER SHIELDS. Makra, S.; Vertes, P. (Magyar Tudomanyos Akademia Kozponti Fizikai Kutato Intezete, Budapest). Nov. 18, 1968. 12p. Dep.

A method for evaluating the neutron spectra as modified by shielding is presented. Some consequences of the changes and complexity of the modified spectra are discussed. The calculations are compared with measured data. Spectra of neutrons transmitted through shields of different materials and different thicknesses are calculated by the code TRAM. This code is based on the formalism of an albedo method and calculates a large number of neutron spectra in a relatively short time. Spectra and fractions of slow, intermediate and fast energy groups are evaluated as a function of shield thickness. The materials considered are water, concrete, iron, iron–concrete mixtures, and lead. The input spectra were both the fission spectrum and the fission spectrum after penetration through water layers of various thicknesses. (M.H.R.)

**20975** (ORNL-RSIC-5(Vol.2)) BIBLIOGRAPHY, SUBJECT INDEX, AND AUTHOR INDEX OF THE LITERATURE EXAMINED BY THE RADIATION SHIELDING INFORMATION CENTER (REACTOR AND WEAPONS RADIATION SHIELDING). Trubey, D. K.; Gurney, J. (Oak Ridge National Lab., Tenn.). Mar. 1969. 465p. Dep. CFSTI.

An indexed bibliography is presented of literature selected by the Radiation Shielding Information Center in the area of radiation transport and shielding against radiation from nuclear reactors, x-ray machines, radioisotopes, nuclear weapons (including fallout), and low-energy accelerators. The bibliography was printed by computer from magnetic tape files. In addition to lists of literature titles by subject category, author and keyword indexes are given. Most of the literature selected was published in the years 1966–1968. (auth)

**20976** YADERNYE VZAIMODEISTVIYA V ZASHCHITE KOSMICHESKIKH KORABLEI. (Nuclear Interactions in Space Ship Protection). Brill', O. D.; Vikhrov, A. I.; Gorodkov, S. S.; Denisov, F. P.; Dudkin, V. E.; Kovalev, E. E.; Lozhkin, O. V.; Ostroumov, V. I.; Smirennyi, L. N. Moscow, Atomizdat, 1968. 264p.

Theoretical and experimental data are given on the energy and angular distribution of secondary nucleons produced during inelastic interactions of 660 MeV protons with aluminum nuclei. The obtained spectra were used for calculating the dose distribution from cascade neutrons, protons, and evaporation neutrons in a tissue-equivalent phantom behind the 30 g/cm$^2$-thick shielding. Curves were developed for attenuation of mean tissue doses from the secondary solar flares and earth radiation belt. It is shown that secondary radiation may produce doses comparable to the doses from primary protons. (tr-auth)

**20977** THE MENE NEUTRON TRANSPORT CODE. Takeuchi, Kiyoshi. Pap. Ship Res. Inst. (Jap.), No. 29, 1-28(Nov. 1968).

The computer program MENE, which was developed for shielding calculations in one-dimensional slab geometry, is described. Numerical solution of the steady-state neutron Boltzmann transport equation is used. The program is written in FORTRAN II. (TSN) (NSA of Japan)

**20978** PRELIMINARY REPORT ON RADIOGRAPHIC HOLDING, PARALLELING, AND SHIELDING DEVICES. J. Amer. Dent. Ass., 77: 884-7(Oct, 1968).

Different adjunctive radiographic devices, which include holding, paralleling, and shielding instruments and auxiliary collimating equipment, are described for use by the dentist. These devices eliminate the need for the patient to hold the film packet in his mouth during an exposure. A few of these devices have additional collimating and shielding features beyond those that are built into some x-ray machines. Precision x-ray devices that were designed by Medwedeff and others provide film holders that eliminate accidental movement of the film packet by the patient's thumb or index finger. The XCP instruments include locator rings and the Precision x-ray devices include cylinder-end, rectangular collimator plates by which the useful beam is aligned with the film. Supplementary rectangular collimators of 1/8 in. stainless steel have been developed for open-end cylinders (cones). The technique involved is flexible and restricts the primary x-ray beam so that there is a 1-cm tolerance beyond the actual film size in the vertical or horizontal direction. The Jong combination of two lead collimators is described. The first collimator has a circular port that is attached to the open end of a plastic long cylinder and the second one has a rectangular port that fits against the first. The rectangular collimation produces a beam of x rays only 0.15 in.$^2$ larger than the film. Modern dental x-ray machines and adjunctive radiographic equipment and techniques reduce the unnecessary radiation to the patient to a level producing no known harm to the patient. Some principles that may further minimize the amount of radiation to the patient are discussed. (BBB)

## Solid-State Physics

*Refer also to abstracts 19707, 19782, 19800, 19936, 19987, and 21232.*

**20979** (CEA-R-3487) CONTRIBUTION TO THE THEORETICAL STUDY OF THE THERMAL DIFFUSION OF POINT DEFECTS IN METALS. Gerl, Maurice (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Nov. 1968. 82p. (In French). Dep.

Thesis. Submitted to Univ. of Paris, Orsay, France.

An experimental study of diffusion under a thermal gradient shows that the heat of transport $\bar{Q}^*$ for self-diffusion in the noble metals is very low (a few hundredths of 1 eV) and relatively large in Fe$\alpha$ (+1.7 ± 0.8 eV). The apparent heat of transport of Sb in Cu, measured by the "thin layer technique" is −0.21 ± 0.05 eV. The influence of the density of sources and sinks of vacancies on the observed vacancy flux is determined by a calculation involving the thermodynamics of irreversible processes; when the mean distance between sources and sinks is larger than a certain limiting value, the vacancy flux vanishes. The contribution to the heat of transport of electron–defect (q*e) and phonon–defect (q*p) collisions is calculated using a semiclassical approach and by a quantum mechanical method; q*e is related to the resistivity $\Delta_{\rho d}$ and to the thermoelectric power of the defect at its stable position and at its saddle point. A relation between q*e and the effective valency Z* of the defect allows a determination of $\Delta_{\rho d}$ at the saddle point. Numerical values of q*e are given for some impurities in noble metals. (auth)

**20980** (JINR-P14-4312) MOESSBAUER EFFECT IN THE $FeS_{1+x}$ SYSTEM. Goncharov, G. N.; Ostanevich, Yu. M.; Tomilov, S. B.; Cher, L. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Neutron Physics). 1969. 21p. (In Russian). Dep.

The composition dependence of the Moessbauer effect in the $FeS_{1+x}$ system is described for $0 \leq x \leq 0.135$ at room temperature. The changes observed in the velocity spectrum parameters are associated with phase transitions and a change of the concentration of iron vacancies. The observed quadrupole splitting is in good agreement with the estimations from the model of point charges. The presence of $Fe^{3+}$ was not detected in the system in the whole investigated composition range. The observed influence of iron vacancies indicates a strong superexchange responsible for the ferromagnetic bond of iron spins in the C plane. The coincidence of the observed phase boundaries with those expected from the consideration of ordering vacancies is noted. (auth)

**20981** (NP-17765) THE CRYSTAL STRUCTURE OF SOME LANTHANIDE OXALATES. Ollendorff, Wolfgang (Munich Univ. (West Germany)). 1968. 163p. (In German). Dep.

Thesis.

The crystal structure of the lanthanide(III) oxalate-10-hydrates $Ln_2(C_2O_4)_3 \cdot 10H_2O$ for Ln = La up to Nd may be considered principally solved. On the basis of the previously evaluated Guinier diagrams of the higher terms of the series, an isotope with the first representation of this compound series can clearly be postulated. The type of lanthanide(III) oxalate-10-hydrate investigated in the present study is characterized by the formation of a layer structure in the simple AB sequence; one of the two layers is composed of the $Ln^{3+}$ cations and the $C_2O_4^{2-}$ anions (anion–cation layer), and the other consists only of water of crystallization (water double layer). The layers are neutral. Each $Ln^{3+}$ cation is surrounded by 6 oxalate and 3 water oxygen atoms at about equal distance, i.e., there is a nine coordination in the arrangement 1:5:3 or 1:4:4. There are complex bound oxalate ions in the form $[Ln(C_2O_4)_3 \cdot 3H_2O]^{3-}$. The lanthanide contraction is shown only two-dimensionally in the plane of the anion–cation layer; the third dimension (b axis) remains constant. The coordination water 0(7), 0(8), and 0(9), 60% of the total water, exerts a double function: in addition to the $Ln^{3+}$ coordination it contributes by H bridges principally to the stabilization of the layer bond. In this function it is supported by the structure water 0(10) and especially 0(11), probably only about 20% of the water of crystallization. The other 20% of the water of crystallization is brought into the lattice probably as interstitial water. In the structure determination, this 40% of the water of crystallization presents much difficulty. It does not indicate at the present that the oxalate decahydrates of Ho, Er, Tm, Yb, Lu, as well as Sc and Y must have the same structural synthesis. An isomorphic replacement of the heavy atoms was assumed, an effect which can be used for the phase determination of acentric structures. (tr-auth)

**20982** (RISO-M-811) COEXISTENCE OF THE COMMENSURATE AND OSCILLATORY MAGNETIC PHASES IN CHROMIUM ALLOYS. Lebech, B.; Mikke, K. (Danish Atomic Energy Commission, Risoe. Research Establishment). Nov. 13, 1968. 10p. Dep.

Detailed neutron diffraction investigations were performed for Cr–Re alloys in which the coexistence of a commensurate and an oscillatory magnetic phase was reported earlier. It is shown that a more reasonable assumption is the occurrence of the individual magnetic phases in separate domains. (Denmark)

**20983** MAGNETIC RESONANCE AT 9.3 GHz OF INTERMETALLIC COBALT–RARE EARTH COMPOUNDS. Marchand, Andre; Lancia, Roland (CNRS, Grenoble, France). Compt. Rend., Ser. A, B, 267: 1323-4(Dec. 16, 1968). (In French).

The values of the resonance field of six cobalt–rare earth compounds ($YCo_3$, $PrCo_3$, $ErCo_3$, $NdCo_3$, $Er_2Co_{17}$, and $Y_2Co_{17}$) at temperatures below and above the Curie temperature $\theta_f$ were given. The existence of a resonance having the characteristics of the ferromagnetic resonance above the $\theta_f$ temperature can be connected to the existence of a very short-distance order in these compounds. (tr-auth)

**20984** SCALING LAWS AND EFFECTS OF IMPURITIES NEAR A CRITICAL POINT. Gluck, P.; Luban, M. (Bar-Ilan Univ., Ramat-Gan, Israel). Phys. Lett., 28A: 607-8(Feb. 10, 1969).

Arguments are presented showing that, contrary to recent claims, specific heat measurements on EuS are neither in conflict with the scaling relation $\alpha' = \alpha$ nor explained by recent theories of the role of impurities near a critical point. (auth)

**20985** STUDY OF 14-MeV NEUTRON-INDUCED DEFECTS IN p-TYPE GERMANIUM. Persin, M. (Ruder Boskovic Inst., Zagreb). Fizika (Zagreb), 1: 97-104(1968).

Gallium-doped germanium samples with initial room temperature resistivities from 2 to 20 Ωcm were bombarded with 14-MeV neutrons at 77°K. The Hall coefficient and the electrical conductivity were measured as a function of neutron fluence. Initial carrier removal rates were determined for a set of samples with different initial hole concentrations, and it was concluded that the limiting Fermi level lies above $E_v + 0.06$ eV. In isochronal annealing measurements performed from 77°K up to room temperature after irradiations three annealing stages were found: the first between 80 and 160°K, the second between 160 and 260°K, and the third above 260°K. The first stage was attributed to certain rearrangements of defects resulting in the increase of the number of donor centers in the gap. The second annealing stage can be connected with cluster dissociation and vacancy migration. The third stage shows no change either in hole concentration or in mobility. (auth)

**20986** X-RAY COLORATION OF SODIUM CHLORIDE CRYSTALS CONTAINING SODIUM COLLOID PARTICLES. Kirin, A.; Kranjc, K. (Univ. of Zagreb). Fizika (Zagreb), 1: 89-95(1968).

The effect of x irradiation on single crystals of sodium chloride containing sodium in stoichiometric excess in the form of colloid particles was investigated by measuring optical absorption spectra. No influence of x rays on colloid particles was found. The concentration of F centers created during the first stage of irradiation was about 2.5 times higher than in pure crystals irradiated with the same dose and was independent of the way in which the colloid particles had been formed. (auth)

**20987** IMPURITY EFFECTS ON ANNEALING OF RADIATION DEFECTS IN SILICON. Fang, P. H. (Electronics Research Center, Cambridge, Mass.); Iles, P. Appl. Phys. Lett., 14: 131-2(Feb. 15, 1969).

A shift of about 100°C is observed in the isochronal annealing temperature of the dominant annealing stage in p-on-n silicon solar cells with a heavy donor concentration of $10^{17}$ $cm^{-3}$ in the n region and low oxygen concentration in the crystal. (auth)

**20988** EXPERIMENTAL EVIDENCE FOR SPONTANEOUS NUCLEAR ORDERING IN PARAMAGNETIC PrBi. Andres, K.; Bucher, E. (Bell Telephone Labs., Murray Hill, N. J.). Phys. Rev. Lett., 22: 600-3(Mar. 24, 1969).

An unexpected ordered state among Pr nuclei in the Van Vleck paramagnet PrBi is inferred from a sharp increase in specific heat at 10 mK as well as from the onset of strong irreversible heating when sweeping the field at these temperatures. Several possible explanations are discussed, among which the coupling between the nuclei via hyperfine interaction (within the ions) and exchange interaction (between the ions) is likely to be the true ordering mechanism. (auth)

**20989** EFFECT OF ALPHA IRRADIATION ON THE THERMAL STABILITY OF CEMENTITE. Stanzl, S. (Univ., Vienna); Weiss, B.; Mitsche, R. Acta Phys. Austr., 27: 112-21(1968). (In German).

An alpha irradiation reduces the thermal stability of pure and alloyed cementite. It produces faults (interstitial atoms, vacancies, vacancy accumulation) and local stresses, which can form germ sites for the resulting graphite. The radiation effect is at least partially reformed at low temperature (liquid nitrogen) storage. (tr-auth)

**20990** COLLISION OF AN ATOM WITH A SOLID FILM. Dolgov, A. S.; Khizhnyak, N. A. (Aeronautical Inst., Kharkov). Sov. Phys.-Solid State (Engl. Transl.), 10: 2083-6(Mar. 1969).

Translated from Fiz. Tverd. Tela, 10: 2647-51(Sept. 1968).

The interaction of an incoming atom, having an energy of the order of a few electron-volts, with a solid film is investigated. The film is represented by a one-dimensional finite chain of elastically coupled atoms. An integral equation is derived which describes the displacement law for the incoming atom, for an atomic chain of any length. The solution to the equation is obtained in the form of a series of Bessel functions. It is shown that the elastic waves excited in the film by the incoming atom have an effect on the adsorption properties of its surface. Some qualitative peculiarities in the dependence of film properties on its thickness are clarified. (auth)

**20991** SCATTERING OF SLOW CESIUM IONS BY THE SURFACE OF A TUNGSTEN SINGLE CRYSTAL. Veksler, V. I. (Tashkent State Univ.). Sov. Phys.-Solid State (Engl. Transl.), 10: 2109-11(Mar. 1969).

Translated from Fiz. Tverd. Tela, 10: 2680-2(Sept. 1968).

An experimental study was made of the dependence of the energy of $Cs^+$ ions scattered by a tungsten single crystal on the angle of incidence of the primary ions in group collisions, for various values of the scattering angle and the energy of the primary particles. Using the experimental results obtained and various theoretical considerations, an estimate is made of the dependence of the repulsion potential Π between an ion and the scattering atoms on the distance between them. It turns out that the interaction can be described satisfactorily in the approximation of absolutely rigid elastic spheres, and the numerical value of Π is close to the value of the potential found by O. B. Firsov at corresponding distances. (auth)

**20992** CHANNELING OF HIGH-ENERGY PROTONS IN IONIC SINGLE CRYSTALS. Shipatov, E. T. (Tomsk Polytechnic Inst., USSR). Sov. Phys.-Solid State (Engl. Transl.), 10: 2132-7(Mar. 1969).

Translated from Fiz. Tverd. Tela, 10: 2709-15(Sept. 1968).

The effect of channeling on the energy distribution of protons with initial energies of 4.7 and 6.72 MeV is shown for protons passing through ionic single crystals of NaCl, KCl, and KBr. The fraction of channeled protons $\eta_k$ in the total number of protons passing through the single crystal is determined, and its dependence on the angles of incidence of the proton beams relative to the crystallographic planes {100} of the single crystals is found. In the {100} planes one observes the passage, with small energy losses, of about 10% of the number of protons passing through the single crystal in directions far off the ⟨100⟩ axes. When the direction of the incident beam of protons coincides with the crystallographic axes ⟨100⟩, the channeling effect becomes most pronounced and $\eta_k$ reaches 20%. The effect of atomic vibrations at lattice sites on proton channeling is shown. For lower proton energies and reduced single-crystal temperatures channeling is expressed more clearly; the half-width of the angular distribution $\alpha_{0.5}$ of the channeled protons and their fraction $\eta_k$ increase. The specific energy losses of protons in a random beam are equal to the losses of protons in amorphous materials of similar chemical composition. In the energy interval considered, the specific energy losses of channeled protons in ionic single crystals are of the order of 0.38–0.42 of the specific energy losses of protons in a random beam. The quantity $\alpha_{0.5}$ is equal to about 0.1° for the crystallographic planes {100}. A comparison of $\alpha_{0.5}$ with the value of the limiting channeling angle $\Psi_{max}$, as calculated using classical proton trajectories in the channel, permits one to conclude that the channeling protons can approach the atomic {100} planes of the single crystals by a distance not less than 0.1 Å. (auth)

**20993** REACTOR-IRRADIATED TIN COMPOUNDS STUDIED BY THE NUCLEAR GAMMA RESONANCE METHOD. Murin, A. N.; Lur'e, B. G.; Bondarevskii, S. I.; Seregin, P. P. (Zhdanov State Univ., Leningrad). Sov. Phys.-Solid State (Engl. Transl.), 10: 2207-8(Mar. 1969).

Translated from Fiz. Tverd. Tela, 10: 2803-6(Sept. 1968).

Moessbauer spectra were measured for SnO, $SnCl_2$, and tetraphenyl tin irradiated in thermal neutron fluxes ($3 \times 10^{18}$ $n/cm^2$-sec) for different times. The source was calcium stannate. For SnO irradiated for 1 min and 70 hr, the spectra contain three lines; the Sn-IV line intensifies with increasing irradiation time. Radiochemical studies were also made, and a tentative radiolysis mechanism is given. For tetraphenyl tin, changes in the spectra

arise only after irradiation for 15 hr; splitting of the singlet line into three components after 70-hr irradiation indicates destruction. For $SnCl_2$, no spectral changes appeared for up to 15 hr. (D.L.C.)

**20994** DENSITY CHANGES AND OPTICAL ABSORPTION OF LiF SINGLE CRYSTALS AFTER IRRADIATION WITH X RAYS. Vladimirskii, Yu. B.; Zakharov, G. M.; Nikitinskaya, T. I.; Reiterov, V. M. (Kalinin Polytechnical Inst., Leningrad). Sov. Phys.-Solid State (Engl. Transl.), 10: 2250-1(Mar. 1969).
Translated from Fiz. Tverd. Tela, 10: 2849-52(Sept. 1968).

The density and optical absorption at the F-band (250 nm) and M-band (450 nm) maxima were measured as a function of irradiation time for the following types of LiF crystals: air-grown; air-grown, doped with 0.02 mole % Mg; and vacuum-grown. A study was made of the slight difference in the behavior of the various crystals by assuming that the main defect type formed during irradiation is Frenkel pairs and that they cause the lattice deformation, while the F centers have practically no effect. (D.L.C.)

**20995** ANOMALOUS PENETRATION OF CHARGED PARTICLES THROUGH A CRYSTAL. Kumakhov, M. A. Sov. Phys.-Solid State (Engl. Transl.), 10: 2254-5(Mar. 1969).
Translated from Fiz. Tverd. Tela, 10: 2854-6(Sept. 1968).

Equations are derived for the energy loss by light channeled particles, such as protons or alpha particles. The contributions from electrons in the ionic core and the valence electrons are considered. Calculations for protons channeled in Si and Ge in the ⟨110⟩ direction are presented. It is shown that the energy losses depend both on the particle velocity and on the target. (D.L.C.)

**20996** CORRELATED CHAINS OF ATOMIC COLLISIONS IN [100] DIRECTIONS IN FACE-CENTERED CUBIC CRYSTALS. Dinyaeva, N. S.; Martynenko, Yu. V.; Ryzhov, Yu. A. Sov. Phys.-Solid State (Engl. Transl.), 10: 2271-3(Mar. 1969).
Translated from Fiz. Tverd. Tela, 10: 2873-5(Sept. 1968).

The focusing effect of neighboring rows are taken into consideration in deriving the recurrence relations for a sequence of correlated collisions in a [100] direction in an fcc crystal. Calculations of the number of collision chains are presented for copper with A = 22.5 keV, D/a = 13. The results show that the number of [100] crowdions with long mean free paths is greater than the estimates of Lenchenko and Pugacheva. The contribution of these crowdions to the formation of stable Frenkel pairs is discussed. (D.L.C.)

**20997** SPUTTERING OF BINARY COMPOUNDS BY LOW-ENERGY $Li^+$ IONS. Martynenko, T. P. Sov. Phys.-Solid State (Engl. Transl.), 10: 2274-5(Mar. 1969).
Translated from Fiz. Tverd. Tela, 10: 2876-8(Sept. 1968).

Sputtering yields were measured for Zr, ZrC, $ZrBr_2$, Nb, and NbC bombarded with $Li^+$ ions at 200, 300, and 400 eV. The results show sputtering sequences of $ZrBr_2$ > ZrC > Zr and NbC > Nb. A plot of sputtering yield vs energy transfer coefficient for six metals shows a linear dependence; a similar plot for four carbides is more complex and falls below the first plot. Possible sputtering mechanisms for explaining the data are given. (D.L.C.)

**20998** BAND STRUCTURE OF CUBIC BN. Aleshin, V. G.; Smirnov, V. P.; Gantsevich, B. V. (Leningrad State Univ.). Sov. Phys.-Solid State (Engl. Transl.), 10: 2282-3(Mar. 1969).
Translated from Fiz. Tverd. Tela, 10: 2884-5(Sept. 1968).

The orthogonal plane wave method was used to calculate the electron band structure of cubic BN. The calculation was done for three directions of the symmetry of the Brillouin zone (Δ, Λ, and Σ). The valence band consists of two subbands with widths of 12.2 and 5.2 eV. The width of the forbidden band is 3.4 eV. (D.L.C.)

**20999** ENERGY MIGRATION AND QUENCHING IN URANYL SALTS AT LOW TEMPERATURES. Abramova, I. N.; Abramov, A. P.; Tolstoi, N. A. Sov. Phys.-Solid State (Engl. Transl.), 10: 2226-7(Mar. 1969).
Translated from Fiz. Tverd. Tela, 10: 2824-6(Sept. 1968).

Nonlinear quenching of luminescence by binary centers was studied in anhydrous $Cs[UO_2(NO_3)_3]$ and $UO_2(NO_3)_2 \cdot 6H_2O$. The nonlinear quenching was observed at all temperatures down to 4.2°K. The binary centers lose their quenching effect at 4.2°K, but regains it when the temperature is raised back to 77°K. The activation energy is $1.9 \times 10^{-3}$ and $1.2 \times 10^{-3}$ eV for $Cs[UO_2(NO_3)_3]$ and $UO_2(NO_3)_2 \cdot 6H_2O$, respectively. (D.L.C.)

**21000** FERROELASTICITY OF NIOBIUM DUE TO HYDROGEN AS A LATTICE GAS. Alefeld, G.; Schaumann, G.; Tretkowski, J.; Voelkl, J. (Kernforschungsanlage, Juelich, Ger.). Phys. Rev. Lett., 22: 697-700(Apr. 7, 1969).

The elastic response of niobium was measured in the region of the critical point of hydrogen in niobium. The elastic susceptibility exceeds commonly observed values by two or three orders of magnitude and follows a Curie-Weiss relation over the temperature range investigated. The diffusion coefficient of hydrogen shows "critical slowing down" behavior but no anomaly in the transport coefficient. (auth)

**21001** OPTICAL ABSORPTION AND DEFECTS IN γ-IRRADIATED SEIGNETTE SALT. Peshikov, E. V.; Mukhteremov, D. N. (Inst. of Nuclear Physics, Tashkent). Izv. Akad. Nauk SSSR, Ser. Fiz., 33: 287-9(Feb. 1969). (In Russian).

The nature of coloring appearing in Seignette's salts (potassium sodium tartarate) and the spectra of irradiated salt in crystalline form and solution were compared using SP-4 device. It was shown that defects in the irradiated salts depended on the temperature of the crystal during irradiation. At 42°C, the net of defects appeared following doses of ~2 Mr while at reduced temperature (~0°C) irradiation with considerably higher doses (6 Mr) did not reveal any defects. Additional thermal treatment at 42°C induced some defects. At lower doses than ~2Mr, thermal treatment was not effective. The strong temperature influence on the results of irradiation indicate the importance of microdefects of coagulative processes connected with thermodiffusion of products of destruction. (R.V.J.)

**21002** MAGNETIC PROPERTIES OF NEODYMIUM COMPOUNDS WITH Va ELEMENTS. Tsuchida, Takashi (Kyoto Univ.); Nakmura, Yoji; Kanekao, Takejiro. J. Phys. Soc. Jap., 26: 284-91(Feb. 1969).

Magnetic properties of NdP, NdAs, and NdSb were investigated over the temperature range from 4 to 300°K. The ratio of the susceptibility at the Neel temperature to the one extrapolated to 0°K is much larger than $3/2$, suggesting that these compounds have large crystal anisotropy. Metamagnetic behaviors were observed at 4.2°K, and the product of the critical field and the susceptibility at the Neel temperature was found to be nearly constant at 7 kOe emu per mole for all of the compounds. This result can be explained by a simple sublattice model. The value of the saturation magnetization and the large anisotropy are discussed in terms of the admixing of the excited state $\Gamma_8$ to the ground state $\Gamma_6$ of $Nd^{3+}$ in a cubic crystal field. (auth)

**21003** NUCLEAR RESONANCE IN METALLIC YTTRIUM. Silhouette, Dominique (Faculte des Sciences, Orsay, France). Compt. Rend., Ser. A, B, 267: 1451-4(Dec. 23, 1968). (In French).

The nuclear resonance of metallic yttrium was studied between 2.2 and 300°K by the method of echoes. The relaxation times were measured, as well as the Knight shift. The observed anomalies can be attributed to the presence of impurities rather than the metal itself. (tr-auth)

**21004** EXPERIMENTAL PROOF FOR PROTON TUNNELING IN $KH_2PO_4$. Plesser, Th.; Stiller, H. (Kernforschungsanlage, Juelich, Ger.). Solid State Commun., 7: 323-6(Feb. 1969).

Elastic and inelastic scattering of neutrons was measured in $KH_2PO_4$ single crystals as a function of the orientation of hydrogen bonds relative to the momentum transfer. The results show that at room temperature the protons tunnel between two equilibrium sites. The distance of the two sites, their orientation relative to the c-axis and an asymmetry parameter are determined. (auth) (UK)

**21005** SCATTERING OF X RAYS AND NEUTRONS. Graf, R.; Raynal, J. M. (Faculte des Sciences, Rouen, France). Rev. Phys. Appl., 3: 321-4(Dec. 1968). (In French).

In a crystal, every deviation from the periodicity involves an anomalous scattering of x rays and of neutrons. The various types of disorders and the corresponding scattering are examined. The principal techniques are described and the advantages of using neutrons are pointed out. (auth)

**21006** MAGNETO-OPTICAL PROPERTIES OF F CENTRES IN ALKALINE EARTH FLUORIDES. Cavenett, B. C.; Hayes, W.; Hunter, I. C.; Stoneham, A. M. (Oxford Univ.). Proc. Roy. Soc. (London), Ser. A, 309: 53-68(Feb. 18, 1969).

The position of the F band peak was determined in additively coloured $CaF_2$, $SrF_2$, and $BaF_2$ by the Faraday rotation method. In additively coloured crystals, the F band is normally overlaid by absorption due to higher F aggregate centres and a determination of the spin orbit coupling constant in the excited $^2P$ state of the F centre is not feasible, since a precise knowledge of the F band optical density is required. It was found that trapped electron centres were produced by x irradiation at 77°K of undoped $SrF_2$ and $BaF_2$ crystals and hydrogen-doped $CaF_2$, $SrF_2$, and $BaF_2$ crystals, and the spin–orbit coupling was determined for these centres. Paramagnetic resonance measurements showed (Bessent, Hayes, Hodby & Smith 1968) that the trapped electron centres are closely

related to the normal F centres found in additively coloured crystals. Wave functions obtained from a point ion model (Bennett & Lidiard 1965) are used to calculate the spin–orbit coupling for the $^2P$ state of the F centre in $CaF_2$, $SrF_2$, and $BaF_2$. For comparison with theory it is assumed that the spin–orbit coupling for the irradiation-induced trapped electron centres is not appreciably different from that for normal F centres, and good agreement between theory and experiment was obtained. (auth) (UK)

**21007** INVESTIGATION OF THE EFFECTS OF X RAYS ON UNDOPED AND ON HYDROGEN-DOPED ALKALINE EARTH FLUORIDES. Bessent, R. G.; Hayes, W.; Hodby, J. W.; Smith, P. H. S. (Oxford Univ.). Proc. Roy. Soc. (London), Ser. A, 309: 69-90(Feb. 18, 1969).

An investigation was made using EPR methods of the effects of x rays on undoped and hydrogen-doped alkaline earth fluorides. It was found that irradiation of undoped $CaF_2$ at any temperature does not produce F centres in observable concentration. Irradiation of undoped $SrF_2$ and $BaF_2$ at 77°K produces $V_k$ centres and trapped electron centres, which anneal out below room temperature. The undoped $SrF_2$ and $BaF_2$ crystals are extremely difficult to colour with room-temperature x irradiation due, apparently, to recombination of electrons and holes. Irradiation of $SrF_2$:H and $BaF_2$:H crystals at 77°K produced hydrogen atoms in fluorine sites ($H_F^0$ centres) and trapped electron centres. The rate of introduction of the electron centres into the crystals was greater by a factor of about 3 than in the undoped crystals. Irradiation of $CaF_2$:H at 77°K also produced $H_F^0$ centres and trapped electron centres, but the rate of generation of the electron centres in these crystals was greater than in undoped $CaF_2$ by a factor of at least 25. The origin of this difference in the behaviour of $CaF_2$:H and the behaviour of $SrF_2$:H and $BaF_2$:H, and the nature of the response of alkaline earth fluorides to x rays, are discussed. The use of polarized bleaching light to extract information from the optical absorption spectrum of irradiated $CaF_2$:H is described in an appendix. (auth) (UK)

**21008** PRODUCTION AND PROPERTIES OF LAYERS OF $Y_2O_3$ AND RARE EARTH OXIDES ON GLASS. Frank, B.; Groth, R. (Philips Zentrallaboratorium GmbH, Aachen). Thin Solid Films, 3: 41-50(Jan. 1969). (In German).

Thin films of $Y_2O_3$ and rare earth oxides were prepared on glass substrates by the spray technique using acetylacetonates. Haze-free films with good adherence are formed at substrate temperatures higher than 400°C. These oxide layers show a crystalline structure with a preferred orientation. Their transmission has been measured in the region from the ultraviolet to the near infrared and their indices of refraction have been determined. The films have an excellent protective effect against corrosion of the glass substrate by hot alkali vapor. (auth)

**21009** A STUDY OF A MANGANESE PARAMAGNETIC CENTER IN IRRADIATED NaCl:$Mn^{++}$ CRYSTALS. Ikeya, Motoji (Nagoya Univ., Japan); Itoh, Noriaki; Suita, Tokuo. J. Phys. Soc. Jap., 26: 291-8(Feb. 1969).

An EPR study of $Mn^{2+}$-doped NaCl irradiated at liquid nitrogen temperature was made at the X- and K-band frequencies. A new paramagnetic manganese center with the principal axes of [100], [010], and [001] and in the extraordinary large crystalline field was found. Rhombic field parameters are obtained to be $D = -1450 \pm 20$ and $E = 107 \pm 10$ gauss by analyzing the K-band spectra. Computer diagonalization of the matrix of the spin Hamiltonian, including the Zeeman and crystalline field energies, is made and the observed X-band spectra are explained qualitatively. Broadening of the line width takes place as the temperature is raised, giving an activation energy of $(0.32 \pm 0.05)$ eV. It is considered that the observed spectra are associated with the complex of an $Mn^{2+}$ and an interstitial halogen ion, and a tentative model is suggested which accounts for the observed experimental results. (auth)

**21010** STUDY BY MOESSBAUER EFFECT OF THE SOLID SOLUTION OF IRON IN BERYLLIUM: VARIATION OF THE ELECTRIC FIELD GRADIENT WITH THE IRON CONCENTRATION. Janot, Christian; Le Caer, Gerard (ENSMIN, Nancy). Compt. Rend., Ser. A and B, 267: 954-7(Oct. 28, 1968). (In French).

Iron, in solid solution in beryllium, was studied by the Moessbauer effect up to a concentration of 0.8%. The distortions of the lattice around solute atoms does not completely take into account the variation of the quadrupolar effect with the composition of the alloy. (tr-auth)

**21011** DETERMINATION OF MEAN INNER POTENTIAL FROM KIKUCHI PATTERNS OF TUNGSTEN SINGLE CRYSTALS. Grote, K. H. v. (Univ., Tuebingen, Ger.). Optik, 28: 374-88 (Jan. 1969). (In German).

Kikuchi patterns from tungsten single crystals are obtained in reflection. Using a special specimen stage the crystals can be heated to 2000°K or cooled to 200°K during observation. The diffracted intensities in the Kikuchi patterns agree qualitatively with those predicted by the Debye–Waller formula. From the diffraction patterns, a mean inner potential of $(24.6 \pm 1.8)$ V is determined. (auth)

**21012** ISOTOPE SHIFT IN THE NMR OF IRON. Turrell, B. G. (Univ. of British Columbia, Vancouver). Can. J. Phys., 47: 697-8(Mar. 15, 1969).

The zero-field NMR frequencies of two samples of iron with different isotopic constitution have been compared at various temperatures. An isotope shift is observed which is different from a previous estimate. A possible explanation for the isotope shift is suggested. (auth) (Canada)

**21013** REMEASUREMENT OF THE CONVERSION CONSTANT Λ. Kirkpatrick, H. A. (Univ. of Southern California, Los Angeles); DuMond, J. W. M.; Cohen, E. R. pp 347-82 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

An experiment attempting to measure the Λ conversion constant for x-rays using a Rowland concave-grating high-vacuum spectrometer is described. (J.W.R.)

## Theoretical Physics

*Refer also to abstract 21067.*

**21014** (ITF-68-57) STATEMENT OF PROBLEMS OF STATISTICAL PHYSICS. Shvarts, A. S. (Akademiya Nauk Ukrainskoi SSR, Kiev. Institut Teoreticheskoi Fiziki). 1968. 44p. (In Russian). (CONF-680453-1). Dep.

From Conference on Axiomatical Field Theory and Theory of Elementary Particles, Kiev, USSR.

The representation of states of the quantum-mechanical system by positive functionals defined on an algebra of observables is investigated. It is shown that, making use of this representation, one can state the problem of determination of the equilibrium state just in an infinite volume. The formalism suggested is used to consider some models of statistical physics. (auth)

**21015** (ORNL–4347) LECTURE SERIES IN STATISTICS AND PROBABILITY. Beauchamp, J. J. (ed.) (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 161p. Dep. CFSTI.

Topics include probability, random variables, and distribution functions; characterizations and limit theorems; contingency tables; confidence regions; distribution-free tests; linear regression; nonlinear estimation; analysis of variance; design of experiments and response surface methodology; and elements of stochastic processes. (W.H.K.)

**21016** SCHROEDINGER EQUATION WITH NONLOCAL POTENTIAL. Talenti, Giorgio (Univ., Catania, Italy). Rend. Semin. Mat. Fis. Milano, 38: 123-36(1968). (In Italian).

Some properties of the eigenfunctions and of the scattering solutions associated with Schroedinger operators which describe a system of two particles interacting through a nonlocal potential are discussed. (auth)

**21017** RELYATIVISTSKAYA KVANTOVAYA TEORIYA. CHAST' I. (Relativistic Quantum Theory. Part I). Berestetskii, V. B.; Lifshits, E. M.; Pitaevskii, L. P. Teoreticheskaya Fizika. Tom IV. Moscow, Izdatel'stvo Nauka Glavnaya Redaktsiya Fiziko-Matematicheskoi Literatury, 1968. 480p.

This book is the first part of the fourth volume of the lectures given by L. D. Landau; the series will contain ten volumes on theoretical physics. The first three chapters are devoted to photon, boson, and fermion concepts and properties. Particles in external fields, Dirac equation for electrons, spin motion in external field, and neutron scattering in electric field are discussed in the fourth chapter. The fifth chapter deals with radiation emission and absorption, atomic and nuclear radiation, magnetic bremsstrahlung, photoeffects, and deuteron photospallation. The scattering of light and matrix scattering are covered in the sixth and seventh chapters. Invariant perturbation theory, Feynman's diagrams for electron and for photon scattering, electron interactions, positronium, and electron interactions with photons are included in the last three chapters. Operators for finite rotations and gyroscopic matrix elements are discussed in the appendix. (R.V.J.)

**21018** DISCONTINUITY OF THE MOMENTUM DISTRIBUTION IN THE GROUND STATE OF A THICK ELECTRON GAS. Zie-

sche, P. (Paedagogische Hochschule, Dresden). Ann. Phys. (Leipzig), 21: 80-4(1968). (In German).

The density dependence of the discontinuity in the one-particle momentum distribution of an electron gas in the high-density-limit ground state is calculated. (auth)

**21019** DERIVATION OF KINETIC EQUATION, UP TO ORDER $\lambda^4$, FOR THE INTERACTION BETWEEN RADIATION AND A TWO-LEVEL SYSTEM. PART I. Henin, F.; de Haan, M. (Univ. Libre, Brussels). Bull. Cl. Sci., Acad. Roy. Belg., 54: 675-711(1968).

In the bare-particle representation, the kinetic operator $\psi(z)$ and its first derivatives play a very important role in the asymptotic equation for the evolution of the diagonal elements of the density matrix. Explicit expressions for these operators are derived, up to order $\lambda^4$, for the interaction between radiation and a two-level system. The transformation to the dressed-particle distribution function will be given in a future paper. (auth)

**21020** FORMAL PROPERTIES OF THE QUASI-PARTICLE DESCRIPTION. Mandel, Paul (Univ. Libre, Brussels). Bull. Cl. Sci., Acad. Roy. Belg., 54: 949-67(1968).

The equivalence between the Heisenberg and Schroedinger pictures is emphasized in the study of mean values in nonequilibrium statistical mechanics. This equivalence leads to a useful definition of adjoint operators. As an application, general theorems are obtained for the mean energy. The second part of this note is devoted to the study of the operator $\Psi_{(z)}$ introduced in nonequilibrium statistical mechanics by I. Prigogine and his coworkers. (auth)

**21021** CHARGED BOLTZMANN GAS OF HIGH DENSITY IN THE REGION OF ABSOLUTE ZERO. Hetzheim, H. (Heinrich-Hertz-Institut, Berlin). Ann. Phys. (Leipzig), 21: 258-62(1968). (In German).

The free energy of a charged Boltzmann gas for low temperature is calculated using the method of collective coordinates. The results are exact at high density. The results are also applicable to a charged boson gas at absolute zero. (auth)

**21022** QUANTUM MECHANICS AS A QUANTUM MARKOVIAN PROCESS. Garczynski, W. (Univ. of Wroclaw). Acta Phys. Pol., 35: 479-81(Mar. 1969).

A new mathematical notion of the quantum Markovian process is introduced and it is shown that it is adequate for the needs of quantum mechanics. (auth)

**21023** CONSERVATION OF A COHERENT STATE DISTRIBUTION. Webber, John C. (Univ. of Calgary, Alberta). Can. J. Phys., 47: 363-5(Feb. 1, 1969).

A certain general P distribution, which corresponds to a Gaussian distribution as a special case, is found to be conserved, with respect to time, for that general class of Hamiltonians which leave coherent states coherent. (auth)

**21024** QUANTUM MECHANICS FOR SCIENCE AND ENGINEERING. Pohl, Herbert A. Prentice-Hall Series in Materials Science. Englewood Cliffs, N. J., Prentice-Hall, Inc., 1967. 123p. $3.95.

Chapters are given on the following: (1) development of a theory, (2) need for quantum theory, (3) principles of wave mechanics, (4) the wave equation, (5) solutions of the wave equation, and (6) periodic potentials and the solid state. (M.O.W.)

**21025** SOME BASIC CONCEPTS OF ALGEBRAIC QUANTUM THEORY. Roberts, J. E.; Roepstorff, G. (Univ., Hamburg). Commun. Math. Phys., 11: 321-38(1969).

After briefly putting algebraic quantum theory into the context of a probabilistic interpretation with emphasis on local measurements, certain general features of the theory are examined. Sectors are defined and shown to be the components of the pure state space in the norm topology. Transition probabilities are defined by a simple algebraic formula and it is shown how superpositions of pure states may be defined. With the aid of these results, symmetries are characterized and the connections with Wigner's Theorem is established. (auth)

**21026** NEW ITERATION METHOD FOR BOUND STATES. Fabri, E. (Univ., Pisa, Italy. Istituto Nazionale di Fisica Nucleare, Pisa, Italy); Fiorio, G. Nuovo Cim., 60B: 210-16 (Mar. 11, 1969).

An iteration method for bound states is presented, starting from an arbitrary function and yielding at the n-th step the same function acted upon by a Chebyshev polynomial of the n-th degree in the Hamiltonian. This method does not require any integration and is of fast convergence. Results are given concerning its application to a three-body problem. (auth)

**21027** RELATION OF THE THEORY OF ELEMENTARY LENGTH TO QUANTUM THEORY. II. Jordan, P. Commun. Math. Phys., 11: 293-6(1969). (In German).

The idea put forward that such algebras that do not fulfill the axiom of power associativity may allow, in some cases, physical interpretation, is illustrated by a mathematical model showing properties similar to the Cartesian coordinates of a particle. (auth)

**21028** THEORETICAL PHYSICS: APPLICATIONS OF VECTORS, MATRICES, TENSORS, AND QUATERNIONS. Kyrala, A. Studies in Physics and Chemistry, Number 5. Philadelphia, W. B. Saunders Company, 1967. 371p. $9.00.

This book is intended to serve the needs of two distinct groups of readers: (1) practicing scientists and engineers who may benefit from mathematical concepts, methods and notations in modern scientific literature, and (2) seniors and graduate students in science or engineering. Topics include vector-function analogies; vectorial Fourier analysis; eigenvalue problems in algebraic, integral, and differential forms; vectorial variational calculus; Green's functions for Sturm–Liouville and vectorial operators; tensors; pseudotensors; matrices; hypercomplex vectors; quaternions; and special relativity. Quantum mechanics is introduced at the beginning and taken through the Dirac equation and explanations of the annihilation and creator operators of second quantization. (L.M.T.)

**21029** OPERATIVE DEFINITION OF THE CONCEPT OF SCATTERING RETARDATION. Kilian, H. (Philipps-Univ., Marburg, Ger.). Ann. Phys. (Leipzig), 21: 244-57(1968). (In German).

An operative definition is described for the notion of a mean collision time delay within the frame of nonrelativistic time-dependent quantum scattering theory. As an application, the collision time delay is calculated for two simple but interesting examples which permit one to make a preliminary calculation of the lifetime of a decaying compound system. (auth)

**21030** TWO-POINT FUNCTIONS. Jeganova, I. A.; Shirokov, M. I. (Physical Inst., Baku. Joint Inst. for Nuclear Research, Dubna, USSR). Ann. Phys. (Leipzig), 21: 225-34(1968).

It is known that the scattering of a low-energy particle by a potential of a small radius of action is satisfactorily described by the s wave alone. A method is given for obtaining functions by means of which the scattering of a particle on two localized potentials separated by an arbitrary distance 2d can be described with the aid of two waves alone. Two-point solenoidal vector functions are also obtained. In the case of two centers they play the same role as the well-known electric and magnetic multipoles in one-center problems (for example, problems of scattering or emission of a photon in the dipole approximation). (auth)

**21031** PERTURBATION THEORY OF NONLINEAR BOUNDARY-VALUE PROBLEMS. Millman, Martin H.; Keller, Joseph B. (New York Univ., N. Y.). J. Math. Phys. (N. Y.), 10: 342-61(Feb. 1969).

A systematic perturbation theory is presented for the analysis of nonlinear problems. The lowest-order result is just that obtained by linearizing the problem, and the higher-order terms are the solutions of inhomogeneous linear problems. The essential feature of the method is the procedure for avoiding secular terms, which is based on the Lindstedt–Poincaré technique employed in celestial mechanics. The method is applied to the following nonlinear boundary-value problems: (1) temperature distribution due to a nonlinear heat source or sink; (2) self-sustained oscillations of a system with infinitely many degrees of freedom; (3) forced vibrations of a "string" with a nonlinear restoring force; (4) superconductivity in a body of arbitrary shape with external magnetic field; (5) superconductivity in an infinite film with parallel magnetic field; (6) comparison of solutions of the Hartree, Fock, and Schrödinger equations for the helium atom. The results in each case are different both qualitatively and quantitatively from those of the linear theory. (auth)

**21032** JETS OF RADIATION. Synge, J. L. (Dublin Inst. for Advanced Studies). Quart. Appl. Math., 26: 153-65(July 1968).

Radiation (scalar, electromagnetic, or gravitational) produced by an extended source is described. The object is to construct a model source from which the radiation is concentrated in a jet of small angle with an assigned target direction. This is done by taking for the source an infinite train of high-frequency plane waves traveling in the target direction with the basic speed of propagation, whose amplitude falls off exponentially with distance. The critical number, to be made large in this model, is the ratio $\alpha/\lambda$, where $\alpha$ is a typical radius of the source and $\lambda$ the wave length. A jet of scalar radiation may also be obtained from a source which possesses no frequency but consists of a single shock wave. Although the equations of hydrodynamics are nonlinear, these equations are assumed to be linearized for the

assumption that the field variables and their derivatives are small of the same order. The validity of this procedure becomes dubious when high frequencies are involved. Another warning also arises for gravitational waves from the physical fact that density cannot be negative. The results need a commonsense interpretation before they are applied to actual physical situations. (BBB)

**21033** IMPROMPTU REMARKS ON THE TREATMENT OF ERRORS. Breitenberger, E. (Ohio Univ., Athens). pp 666-9 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

The statistical treatment of uncertainties in experimental measurements and theoretical calculations is described. The problem of terminology is described. (J.W.R.)

# PHYSICS (HIGH ENERGY)

## Particle Interactions and Properties (Experimental)

*Refer also to abstract 21063.*

**21034** (PPAR-9) RESEARCH REPORT BY THE PRINCETON-PENNSYLVANIA ACCELERATOR FOR 1968. (Princeton-Pennsylvania Accelerator, Princeton, N. J.). 1968. Contract AT(30-1)-2137. 21p. Dep. CFSTI.

High-energy physics research and accelerator development at the Princeton–Pennsylvania Synchrotron are summarized. (W.H.K.)

### Electromagnetic

*Refer also to abstracts 20735 and 21211.*

**21035** (ORNL-tr-3022) STUDY OF ELECTRON–PHOTON SHOWERS PRODUCED BY γ-QUANTA WITH ENERGIES OF 100, 200, 500, AND 2000 MeV IN LIQUID XENON. Slovinskii, E.; Strugal'skii, Z. S.; Yanovskaya, B. ([Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy]). Translated for Oak Ridge National Lab., Tenn., from report JINR-P1-3919. 12p. Dep. CFSTI.

The fluctuations of the longitudinal development of showers caused by γ quanta with energies of 100, 200, 500, and 2000 MeV were studied by means of a xenon bubble chamber. Some properties of a cascade process in the medium are deduced from this experiment and listed. (J.F.P.)

**21036** PHOTODISINTEGRATION OF THE DEUTERON FROM 220 TO 340 MeV. Anderson, R. L.; Prepost, R.; Wilk, B. H. (Stanford Univ., Calif.). Phys. Rev. Lett., 22: 651-4(Mar. 31, 1969).

The differential cross section for the photodisintegration of the deuteron was measured at laboratory photon energies of 222, 254, 302, 342 MeV in steps of 10° between 20 and 160° in the center-of-mass system. (auth)

**21037** PHOTOPRODUCTION OF VECTOR MESONS AND OTHER RESONANCES AT 4.3 BeV. Eisenberg, Y.; Haber, B.; Carmel, Z.; Peleg, E.; Ronat, E. E.; Shapira, A.; Vishinsky, G.; Yaari, R.; Yekutieli, G. (Weizmann Inst. of Science, Rehovot, Israel). Phys. Rev. Lett., 22: 669-73(Mar. 31, 1969).

The Stanford Linear Accelerator Center 40-in. hydrogen bubble chamber was exposed to 4.3-GeV positron-annihilation radiation. Results are presented on reactions containing no neutrals and one neutral particle in the final state. For $\gamma p \to \rho^0 p$ and $\omega^0 p$ cross sections of 19.2 ± 1.2 and 2.8 ± 0.5 μb, respectively, are found. Assuming vector dominance, the $V^0 p$ cross sections are determined. Evidence for other resonant states is presented, in particular $\Delta^{2+} V^0 \pi^-$, where $\Delta^{2+}\rho^0\pi^-/\Delta^{2+}\omega^0\pi^-$ about 1.5 is found. (auth)

**21038** PHOTOPRODUCTION OF VECTOR MESONS WITH A 16 GeV BREMSSTRAHLUNG BEAM. Davier, M.; Derado, I.; Drickey, D.; Fries, D.; Mozley, R.; Odian, A.; Villa, F.; Yount, D. (Stanford Univ., Calif.). Phys. Lett., 28B: 619-22(Mar. 3, 1969).

The high-energy cross sections and t distributions for ω and φ photoproduction were measured. Using the published $\rho^0$ data, these results and their vector dominance model, the total hadronic photon-proton cross sections were calculated obtaining values in good agreement with direct measurements. (auth)

**21039** PHOTOPRODUCTION OF NEUTRAL PIONS ON PROTONS NEAR THRESHOLD. Hitzeroth, W. (Max-Planck-Institut fuer Physik und Astrophysik, Munich). Nuovo Cim., 60A: 467-80 (Apr. 1, 1969).

At the Bonn 500 MeV electron synchrotron the reaction $\gamma + p = p + \pi^0$ was studied for energies below $E_\gamma$ = 222 MeV using nuclear emulsions inside a low-pressure hydrogen gas target to detect the recoil protons. Angular distributions of the neutral pion were obtained for the energies $E_\gamma$ = 159, 180, 206 MeV (or, alternatively, $E_\gamma$ = 166, 195 MeV with a different grouping of tracks). In general they are in good agreement with other experimental data in the same energy region, and join also smoothly to recent measurements at higher energies. The agreement with recent theoretical approaches is fairly good in the coefficients A and B of the expansion $d\sigma/d\Omega = A + B\cos\psi + C\cos^2\psi$, but the theoretical values of the coefficient C are definitely too positive. (auth)

**21040** REMARKS ON A POSSIBLE DIRECT PRODUCTION OF MUONS. Etim, E. (Univ. of IFE, Ibadan, Nigeria); Picchi, P. Nuovo Cim., Lett., 1: 453-8(Mar. 21, 1969).

A survey is given of experimental facts which cannot be accommodated in a model of direct cosmic muon production with the photonuclear cross section increasing with the transferred energy. (J.F.P.)

**21041** A MEASUREMENT OF $\mu_p/\mu_N$ WITH A QUADRUPOLE OMEGATRON. Petley, B. W.; Morris, K. (National Physical Lab., Teddington, Eng.). pp 461-77 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.
See CONF-670818.

Using a quadrupole omegatron, the magnetic moment of the proton in units of the nuclear magneton 2.79282 ± 0.00005. (J.W.R.)

**21042** THE g-FACTOR OF THE FREE ELECTRON AND OF THE FREE POSITRON. Rich, Arthur (Univ. of Michigan, Ann Arbor). pp 383-409 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.
See CONF-670818.

Experiments currently being done to measure the g-factor of the free electron and positron are described. The measurements should give a precise value of the g-factor anomaly "a" and the fine structure constant α. (J.W.R.)

**21043** MEASUREMENT OF THE MAGNETIC MOMENT OF THE PROTON IN UNITS OF THE NUCLEAR MAGNETON BY MEANS OF A MAGNETIC RESONANCE MASS SPECTROMETER. Mamyrin, B. A.; Frantsuzov, A. A. (Ioffe Inst. of Physics and Tech., Leningrad). pp 427-36 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.
See CONF-670818.

Using a magnetic resonance mass spectrometer, the magnetic moment of the proton in units of the nuclear magneton and uncorrected for diamagnetism was measured to be 2.792794 ± 0.000015. (J.W.R.)

### Weak

*Refer also to abstract 21154.*

**21044** (NP-17758) INTERFERENCE BETWEEN THE $\pi^+\pi^-$ DECAYS OF $K_S$ and $K_L$ MESONS AND THE $K_S - K_L$ MASS DIFFERENCE. Kleinknecht, Konrad (Heidelberg Univ. (West Germany)). 1966. 139p. (In German). Dep.
Thesis.

A beam of neutral $K_L$ mesons, produced in an internal target of the CERN proton synchrotron, hit a copper regenerator of various effective density. The time distribution of the $K^0 \to \pi^+\pi^-$ decays behind the regenerator was investigated with the help of a spectrometer consisting of a magnet and four optical spark chambers. A counter hodoscope was used for the kinematic evaluation of the events selected. The measured time distribution shows the interference between the CP violating decays $K_L \to \pi^+\pi^-$ with the $\pi^+\pi^-$ decays of coherent regenerating $K_S$ mesons. The observed distribution corresponds well with a calculated distribution with the parameters $\Delta m = m_L - m_S = \pm(0.445 \pm 0.034)\cdot\Gamma_S$, $\varphi_n - \varphi_f = \pm(1.42 \pm 0.20)$ rad, $\Gamma_S = (1.155 \pm 0.021)\ 10^{10}\ \text{sec}^{-1}$; Δm is the mass difference between $K_L$ and $K_S$ mesons, $X\ \Gamma_S = \hbar/\tau_S$ the decay rate of the $K_S$ meson, $\varphi_n$ the phase difference between the transition amplitudes $\langle K_S|T|\pi^+\pi^-\rangle$ and $\langle K_L|T|\pi^+\pi^-$ and $\varphi_f = \text{Arg}\{i[f(0) - \bar{f}(0)]\}$, when f(0) or $\bar{f}(0)$ is the forward scattering amplitude for $K^0$ or $\bar{K}^0$ mesons in copper. For the decay of $K_L$ mesons into lepton pairs, the following upper limits of the branching ratios relative to the lepton decay rate $\Gamma_L$ were found: $\Gamma(K_L \to \pi^+\pi^-)/\Gamma_L < 2.0\cdot10^{-4}$ and $\Gamma(K_L \to e^+e^-)/\Gamma_L < 1.6\cdot10^{-4}$ with 95% confidence. (tr-auth)

**21045** THE DECAY $\Sigma^\pm \to \Lambda e^\pm \nu$. Baltay, C. (Columbia Univ., New York, N. Y. Brookhaven National Lab., Upton, N. Y.); Franzini, P.; Newman, R.; Norton, H.; Yeh, N.; Cole, J.; Lee-Franzini, J.; Loveless, R.; McFadyen, J. Phys. Rev. Lett., 22: 615-18(Mar. 24, 1969).

There were 46 examples of the decay $\Sigma^- \to \Lambda e^-\nu$ and six of the decay $\Sigma^+ \to \Lambda e^+\nu$ observed. The branching ratios are, respectively, $(0.52 \pm 0.09) \times 10^{-4}$ and $(0.16 \pm 0.07) \times 10^{-4}$. A study of the internal variables distribution yields $G_V/G_A = -0.7 \pm 0.4$ for the combined sample of $\Sigma^\pm \to \Lambda e^\pm \nu$. (auth)

**21046** STUDY OF $K_1^0 \to \pi^0\pi^0$ AND $K_2^0 \to \pi^0\pi^0$ INTERFERENCE. Gobbi, B.; Green, D.; Hakel, W.; Moffett, R.; Rosen, J. (Univ. of Rochester, N. Y.). Phys. Rev. Lett., 22: 685-8(Mar. 31, 1969).

Using $K^0$'s produced by the charge exchange of $K^+$, the proper-time dependence of the decays $K^0 \to \pi^0\pi^0$ was measured. Analysis indicates that a third-quadrant solution for the phase of $\eta_{00}$ is unfavored by more than 2 standard deviations. A first-quadrant solution is acceptable. (auth)

**21047** TEST OF THE $\Delta S = \Delta Q$ RULE IN $K^0 \to \pi e \nu$ DECAY. Littenberg, L. S.; Field, J. H.; Piccioni, O.; Mehlhop, W. A. W.; Murty, S. S.; Bowles, P. H.; Burnett, T. H. (Univ. of California, San Diego, La Jolla). Contract AT(11-1)-Gen-10. Phys. Rev. Lett., 22: 654-8(Mar. 31, 1969).

$K^0$'s were produced by the charge exchange of $K^+$'s in Cu targets and the subsequent decays observed in a spark chamber situated in a magnetic field. The time distribution of 686 selected events yields $Re x = 0.09 \pm 0.15$, $Im x = -0.11 \pm 0.11$ if x is allowed to be complex, and $x = 0 \pm 0.12$ if x is constrained to be real. Thus, while several previous chamber results seemed to converge on $x \simeq 0.2$ as the most probable value, the data shift somewhat the likelihood distribution in favor of the $\Delta S = \Delta Q$ rule. (auth)

**21048** MEASUREMENT OF THE $K_1^0$ CHARGED-TO-NEUTRAL DECAY BRANCHING RATIO. Gobbi, B.; Green, D.; Hakel, W.; Moffett, R.; Rosen, J. (Univ. of Rochester, N. Y.). Phys. Rev. Lett., 22: 682-5(Mar. 31, 1969).

Using $K^0$ produced by $K^+$ charge exchange in Be, the charged-to-neutral branching ratio of $K_1^0$ was measured. The ratio $2.285 \pm 0.055$ is obtained to be compared with the $|\Delta I| = 1/2$ rule prediction of 2.00. This 5-standard-deviation violation gives $Re(A_2/A_0)\cos(\delta_2 - \delta_0) = 0.0345 \pm 0.007$. (auth)

**21049** BINDING ENERGY AND $\pi^+$ DECAY OF LIGHT HYPERFRAGMENTS. Chaudhari, K. N. (Tata Inst. of Fundamental Research, Bombay); Ganguli, S. N.; Rao, N. K.; Swami, M. S.; Gurtu, A.; Kohli, J. M.; Singh, M. B. Proc. Indian Acad. Sci., Sect. A, 68: 228-43(Nov. 1968).

Binding energy values of hyperfragments from a sample of 541 uniquely identified mesic decays with mass numbers A = 3 to 14 are presented. There does not seem to be any detectable difference in the binding energy value of $\Lambda$ in $_\Lambda H^4$ obtained from its two-body and three-body decay modes. Within statistical error, the binding energy values of $\Lambda$ in $_\Lambda H^4$ and $_\Lambda He^4$ are also the same. From a sample of $2\pi^+$ decay events of hyperfragments the branching ratio of $_\Lambda He^4$ decaying by $\pi^+$ to $\pi^-$ mode is found to be $(1.5 \pm 1.0)\%$. (auth)

## *Strong (Baryon-Induced)*

**21050** (JEN-195-IFIC/I-59) THE FRAGMENTATION OF HEAVY NUCLEI BY 13.8-GeV/c PROTONS AS A CONTRIBUTION TO THE STUDY OF THE INTERACTION MECHANISM AND NUCLEAR STRUCTURE. Gil Perez, D. (Junta de Energia Nuclear, Madrid (Spain). Division de Fisica). Aug. 1967. 17p. (In Spanish). Dep.

A global study of the interaction between high-energy particles and heavy nuclei, an interaction which holds obvious interest in relation to the problems of nuclear fragmentation and which, up to now has only been studied piecemeal is presented. Three stacks of photographic emulsions were used which were irradiated by 13.8 GeV/c protons, 17 GeV/c negative pions and 24 GeV/c protons. All three irradiations took place in a 180 K.G. magnetic field using CERN beams. A complete phenomenological study of all the tracks due to secondary or fragment emission following the interaction between the incoming particle and the heavy nuclei (Ag and Br) of the emulsion is presented. Measurements of emission angle and energy as well as the classification of all particles by charge are given. An original method for the discrimination of recoils is explained. The energy spectra and angular distribution obtained have permitted the experimental separation of groups of fragments corresponding to the two distinct emission mechanisms, evaporation and cascade, for particles of any charge including charge-one particles. Some of the many consequences of this experimental separation into particles emitted by either mechanism are investigated. One of the most important results is the reduction of the nuclear temperature achieved using only the particles which correspond to the evaporation phase. (auth)

**21051** SMALL-ANGLE d-p ELASTIC SCATTERING AT 1.69 GeV/c. Dutton, L. M. C.; Howells, R. J. W.; Jafar, J. D.; van der Raay, H. B. (Univ. of Birmingham, Eng.). Nucl. Phys., B9: 594-604(1969).

The differential cross section for elastic dp scattering was measured over the angular range 18-70 mrad. These data when analysed gave a value of $0.05 \pm 0.20$ for the ratio of the real to imaginary parts of the spin independent n-p scattering amplitude at 0.845 GeV/c, in good agreement with the predictions of forward N-N dispersion relations. (auth)

**21052** ANALYSIS OF ANGULAR DISTRIBUTION DATA ON (n,p) SCATTERING BELOW 10 MeV. Czibok, Tamas. KFKI (Kozp. Fiz. Kut. Intez.) Kozlem., 16: 401-6(1968). (In Hungarian).

In connection with the current n-p scattering investigations, the reported experimental data below 10 MeV were analyzed. In contrast with the generally assumed isotropy of the angular distributions in the range of energies below 10 MeV, the analysis of even the sparse data available in this range suggests the presence of a more complex structure in the differential cross section. (auth)

**21053** OSCILLATIONS IN THE ENERGY DEPENDENCE OF THE n-p SCATTERING CROSS SECTION. Hrehuss, Gy.; Czibok, T. (Central Research Inst. for Physics, Budapest). Phys. Lett., 28B: 585-7(Mar. 3, 1969).

A small but statistically significant periodical fluctuation was found in the energy dependence of the cross section for neutron-proton scattering at low neutron energies. (auth)

## *Strong (Meson-Induced)*

*Refer also to abstract 21050.*

**21054** (COO-1195-159) THE PI-MINUS PROTON OMEGA CHANNEL IN PI-MINUS PROTON INTERACTIONS AT FIVE GeV. Shapiro, Alexander (Illinois Univ., Urbana. Dept. of Physics). 1969. Contract AT(11-1)-1195. 58p. Dep. CFSTI.

Thesis.

The results of an investigation of the reaction $\pi^- p \to \pi^- p\omega$ at an incident pion momentum of 5 BeV/c are presented. The data for this study were obtained with the Alvarez 72-inch hydrogen bubble chamber. $N^{*0}$ production and B production were both observed. From a moment analysis of the angular distributions in the sequential decays $B \to \omega\pi$, $\omega \to 3\pi$, the B is found to have either $J^P = 1^+$ or $J^P = 2^+3^-4^+ \ldots$. A qualitative argument against the $J^P = 2^+3^-4^+ \ldots$ assignments is made on the basis of the observed polarization of the B. (auth)

**21055** HIGH-ENERGY MUON INELASTIC SCATTERING. Hoffman, C. M. (Harvard Univ., Cambridge, Mass.); Liberman, A. D.; Engels, E. Jr.; Imrie, D. C.; Innocenti, P. G.; Wilson, Richard; Zajde, C.; Blanpied, W. A.; Stairs, D. G.; Drickey, D. Phys. Rev. Lett., 22: 659-63(Mar. 31, 1969).

Muon inelastic scattering was measured using muons with momenta between 8.6 and 12.9 GeV/c striking a carbon target. The virtual-photoproduction cross section is presented as a function of the four-momentum transfer from the muon. (auth)

**21056** ENERGY DEPENDENCE OF THE 180° $\pi^- p$ CHARGE-EXCHANGE CROSS SECTION. Kistiakowsky, V. (Massachusetts Inst. of Tech., Cambridge); Yamamoto, R. K.; Klem, R. D.; (and others). Phys. Rev. Lett., 22: 618-21(Mar. 24, 1969).

Preliminary data are presented which demonstrate that the $\pi^- p$ charge-exchange differential cross section at 180° in the momentum region between 1.8 and 5.0 BeV/c is quite similar in shape to the elastic $\pi^+$ differential cross sections at 180°. (auth)

**21057** STUDY OF THE REACTIONS $K^- n \to \Lambda\pi^-$ AND $K^- n \to \Sigma^{\delta}\pi^{\delta}$ AT 3 GeV/c. Barloutaud, R. (CEN, Saclay, France); Hoa, Duong Nhu; Griselin, J.; (and others). Nucl. Phys., B9: 493-500(1969).

The total and differential cross sections of the reactions $K^- n \to \Lambda\pi^-$, $K^- n \to \Sigma^0\pi^-$ and $K^- n \to \Sigma^-\pi^0$, as well as the $\Lambda$ polarization in the first reaction, were measured at an incident $K^-$ momentum of 3 GeV/c. (auth)

**21058** A STUDY OF DIFFRACTION-PRODUCED $K^*\pi$ AND $\Delta\pi$ SYSTEMS IN 12.6-GeV/c $K^- p$ INTERACTIONS. Andrews, J. (Yale Univ., New Haven); Lach, J.; Ludlam, T.; Sandweiss, J.; Taft, H. D.; Berger, E. L. Contract AT(30-1)-12726. Phys. Rev. Lett., 22: 731-5(Apr. 7, 1969).

Two different peripheral quasi three-body final-state processes are studied in the reaction $K^- p \to K^- p\pi^+\pi^-$. Near-threshold mass enhancements are observed in both the $\bar{K}^{*0}(890)\pi^-$ and $\Delta^{++}(1238)\pi^-$ systems. In both cases the data are suggestive of a production mechanism involving inelastic diffraction scattering. For each case a comparison is made with the predictions of a double-Regge-pole exchange model. (auth)

**21059** $K^+ p$ ELASTIC SCATTERING AT 7.3 GeV/c. Chien, Chih-yung; Malamud, E.; Mellema, D. J.; Schlein, P. E.; Slater, W. E.; Stork, D. H.; Ticho, H. K. (Univ. of California, Los Angeles). Phys. Lett., 28B: 615-18(Mar. 3, 1969).

A study of $K^+ p$ elastic scattering at 7.3 GeV/c has yielded a cross section of $3.86 \pm 0.38$ mb. For events produced in the forward direction, a diffractive peak is observed which fits the dis-

tribution $(d\sigma/dt) = (d\sigma/dt)_0 \exp(\alpha t + \beta t^2)$ with $(d\sigma/dt)_0 = (20.6 \pm 2.6)$ mb/(GeV/c)$^2$, $\alpha = (5.46 \pm 0.29)$(GeV/c)$^{-2}$ and $\beta = (0.38 \pm 0.25)$ (GeV/c)$^{-4}$. The ratio $|\mathrm{Re}f(0)/\mathrm{Im}f(0)|$ for the forward scattering amplitude is $0.60 \pm 0.14$. One elastic scatter was found in the backward direction. (auth)

**21060** ELASTIC SCATTERING OF POSITIVE KAONS ON POLARIZED PROTONS AT 1.22 AND 2.48 GeV/c. Andersson, S.; Daum, C.; Erne, F. C.; Lagnaux, J. P.; Sens, J. C.; Udo, F. (CERN, Geneva). Phys. Lett., 28B: 611-14(Mar. 3, 1969).

Polarization angular distributions of $K^+p$ elastic scattering were measured at 1.22 and 2.48 GeV/c. Over the measured range of -t the polarization is generally large and positive. The data at 1.22 GeV/c resolve an ambiguity in a recently published phase-shift analysis, favoring the solution which requires no resonance in the $K^+p$ system. (auth)

**21061** SOME RESULTS CONCERNING $K^-d$ INTERACTIONS AROUND 900 MeV/c. Delaney, W. C. (Brookhaven National Lab., Upton, N. Y.); London, G. W.; Guidoni, P.; Martellotti, G. Nuovo Cim., Lett., 1: 497-501(Apr. 1, 1969).

Evidence for the breakdown of the impulse approximation in the deuteron for the reaction $K^- + d \rightarrow \Sigma^- + \eta + p$ at threshold is presented. Also results concerning the reactions $K^- + n \rightarrow \Lambda(1405) + \pi^-$ and $K^- + n \rightarrow \Lambda(1520) + \pi^-$ are given. (J.F.P.)

**21062** AN ATTEMPT TO ESTABLISH AN UPPER LIMIT FOR THE PRODUCTION CROSS-SECTION OF A NEUTRAL BOSON IN THE 400 MeV MASS REGION. Bradamante, F. (Univ., Trieste, Italy. Istituto Nazionale di Fisica Nucleare, Trieste, Italy); Giorgi, M.; Sauli, F.; Schiavon, P.; Fidecaro, M. Nuovo Cim., Lett., 1: 505-8(Apr. 1, 1969).

Data collected in a previous experiment, of which the purpose was to study the neutral decay models of the $\eta$, are analyzed. The bosons were to be produced in 1.2 GeV/c $\pi^-$ beam reactions with protons. It is concluded that a relatively narrow resonance such as one indicated by current algebra if it exists at all is produced with a cross section three or ten times smaller than the cross section computed using the OPE model. (J.F.P.)

# Particle Interactions and Properties (Theoretical)

## General

**21063** (UCRL-18619) PHYSICS SEMIANNUAL REPORT, MAY-OCTOBER 1968. (California Univ., Berkeley. Lawrence Radiation Lab.). Nov. 1968. 181p. Dep. CFSTI.

A report on research on experimental and theoretical high-energy physics at the Lawrence Radiation Laboratory is given. Also health physics, mathematics and computing, and the operation and development of accelerators are covered. (J.F.P.)

**21064** BILINEAR EXPRESSIONS FOR FIELDS WITH 2(2s + 1) COMPONENTS. Gabos, Zoltan. Rev. Roum. Phys., 13: 731-4(1968). (In French).

Assuming the spherical base and the helicity representation, it is shown that it is possible to separate the radial variables from the angular variables in the bilinear expressions concerning the particles 1 and 2 with spin s. The result obtained makes it possible to interpret the bilinear expressions as spin kinetic moment currents. (tr-auth)

**21065** CONFORM INVARIANCE OF EQUATIONS DESCRIBING PARTICLES WITH ARBITRARY SPIN. Chikvashvili, Ya. M. Acta Phys. Pol., 35: 459-65(Mar. 1969). (In Russian).

Conform invariance of wave equations describing arbitrary spin particles was studied. (tr-auth)

**21066** n-PARTICLE PHASE SPACE IN TERMS OF INVARIANT MOMENTUM TRANSFERS. Byckling, E. (Univ. of Oulu, Finland); Kajantie, K. Nucl. Phys., B9: 568-76(1969).

A new recursion relation relating the n-particle phase space integral $R_n$ to $R_{n-1}$ is derived. Using this, $R_n$ is transformed into a form in which the n-1 independent invariant momentum transfers $t_i$ from one of the incoming particles to the final state particles appear as variables. If this form is used as a basis for Monte Carlo generation of events, the strong cut-offs in the $t_i$ caused by, e.g., multiperipherism are easily imposed. A further advantage of this form is that all the momentum vectors can be generated in a single frame; a disadvantage is that the limits of integration become interdependent. (auth)

**21067** SEQUENT CORRELATIONS IN STOCHASTIC POINT PROCESSES. III. Srinivasan, S. K. (Indian Inst. of Tech., Madras); Koteswara Rao, N. V.; Vasudevan, R. Nuovo Cim., 60B: 189-92(Mar. 11, 1969).

Sequent correlations play a vital role in the study of stochastic point processes. The feasibility is demonstrated of defining a single characteristic functional from which various types of sequent correlations useful in branching phenomena can be obtained by appropriate functional differentiation. (auth)

**21068** PARTICLES AND SOURCES. Schwinger, Julian. Documents on Modern Physics. New York, Gordon and Breach, Science Publishers, 1969. 100p.

A new approach to particle physics based on the source concept is described, which is intermediate in concept between two previous formulations. The topics covered include noninteracting particles, electrodynamics, and strong and weak interactions. (L.B.S.)

**21069** GENERALIZED CONCEPT OF SPACE. Smrz, P. (Univ. of Alberta, Edmonton). Nuovo Cim., Lett., 1: 488-92 (Apr. 1, 1969).

Possible ways to remove space–time variables from the description of the interior of the elementary particles and retain the interpretation of a particle as a particlelike solution of basic differential equations are considered. A universal field being closely connected with the metric of space is discussed. The generalization is made that perhaps the whole Poincaré group would never play as important a role in any physical theory if the metric tensor of certain generalized space were not very close to a special form. (J.F.P.)

**21070** REMARK ON THE RULE OF TRANSFORMATION OF ACTUAL BEAMS OF ELEMENTARY PARTICLES. Goldberg, H.; Tatarko, A. (Tel-Aviv Univ.). Nuovo Cim., Lett., 1: 493-6 (Apr. 1, 1969).

The discussion of the rule of transformation of actual beams of elementary particles covers freedom in the definition of one-particle states, and the physical determination of transformation properties. (J.F.P.)

## Electromagnetic

*Refer also to abstracts 21097, 21153, and 21180.*

**21071** SIDEWISE DISPERSION RELATIONS AND J = ½ BARYON RESONANCES. Love, A.; Moorhouse, R. G. (Glasgow Univ.). Nucl. Phys., B9: 577-93(1969).

Sidewise dispersion relations are extended to calculate d/(f + d), using current-field commutation relations as in the calculation of $g_A/g_V$ by Suura and Simmons. Using a (J = ½ baryon) resonance dominance model the relation between the sidewise dispersion relation calculations of nucleon magnetic moments and $g_A/g_V$ is examined. (auth)

**21072** THE $\eta - x^0$ MIXING ANGLE AND THE $\kappa$ MESON. Schuelke, Lothar (Weizmann Inst. of Science, Rehovoth, Israel). Phys. Rev. Lett., 22: 626-8(Mar. 24, 1969).

The SU(3) singlet-octet mixing angle between $\eta$ and $x^0$ is expressed in terms of the masses of the members of the pseudoscalar meson nonet and a scalar strange meson $\kappa$. Using the recent experimental value $m_\kappa = 1100$ MeV, one obtains $\theta = 23°$, or $\theta = 14°$, depending on whether the angle is defined for mesons being at rest or moving with infinite momentum. (auth)

**21073** ELECTROMAGNETIC PROPERTIES OF THE BARYONS IN THE CAPPS BOOTSTRAP MODEL. Noga, M. (Univ. of Helsinki). Nucl. Phys., B9: 481-92(1969).

The electromagnetic properties of the P-wave baryons are calculated using the Capps bootstrap assumptions for the photomeson production processes in the static model. The magnetic moments are expressed in terms of two free parameters which are fitted to the magnetic moments of the proton and neutron. The electromagnetic mass differences following from this bootstrap scheme are completely consistent with the results of SU(6). It is pointed out that Capps bootstrap assumptions completed by various requirements can reproduce exactly the results following from all group-theory treatments. (auth)

**21074** INFRARED RADIATIVE CORRECTIONS FOR RESONANT PROCESSES. Pancheri, G. (CNEN, Frascati, Italy). Nuovo Cim., 60A: 321-9(Mar. 21, 1969).

The infrared radiative corrections to be applied to electron colliding beam experiments are given a nonperturbative treatment, which extends the method of Etim, et. al (Nuovo Cimento, 51 B 276(1967)) to processes which take place through an intermediate resonant state, i.e., for which the high and low energy aspects can no longer be assumed to be separable. The resulting correction factor is compared with lowest order perturbation theory. The approximations to be applied for such cases as $\omega$, $\varphi$ or $\rho$ as an intermediate state are discussed. (auth)

**21075** FIELD-THEORETIC MODEL FOR ELECTRON–NUCLEON DEEP INELASTIC SCATTERING. Drell, Sidney D.; Levy, Donald J.; Yan, Tung-mow (Stanford Univ., Calif.). Phys. Rev. Lett., 22: 744-9(Apr. 7, 1969).

The structure functions for inelastic electron-nucleon scattering are studied in the Bjorken limit in the framework of canonical field theory. The "parton" model of Feynman is derived and the structure functions' asymptotic behavior for large energy transfers is computed. (auth)

**21076** RECENT DEVELOPMENTS OF THE ALGEBRA OF CURRENTS. De Alfaro, V.; Rosetti, C. (Univ., Turin. Istituto di Fisica Nucleare, Turin). Nuovo Cim., Suppl., 6: 575-601(1968). (In Italian).

For a clearer comprehension of the origin and significance of many recent results from current algebra, some well known results on electromagnetic interactions are first summarized. The 2 octets of weak currents are considered and it is shown how the results of electrodynamics can be generalized by these currents. The Ward identity is generalized. The theory of soft pions is developed with a consideration of the axial current which conserves the strangeness. New scattering formulation of the low energy theorem is given. (J.S.R.)

**21077** ETA-PARTICLE. Salvini, G. (Univ., Rome). Riv. Nuovo Cim., 1: 57-159(Jan.-Mar. 1969).

The history of the theoretical anticipation of the eta and of the experiments that established its quantum numbers is treated in Chapter I, which ends with the definitive attribution of spin zero to the eta particle. The experimental results of the production of the eta particle are reported in Chapter II. The theoretical discussion of the production experiments follows in the next chapter. It is shown in fact that the eta-baryon resonances near threshold, which appear in all production channels, may perhaps be represented together in a single octet. The end of this chapter is devoted to the Primakoff production, and it is therefore a link to the following study of the decays of the eta. The experimental results of the decays of the eta are presented in Chapter IV; the theory follows in Chapter V. Chapter VI is devoted to tests of C invariance in the decays $\pi^+\pi^-\pi^0$ and $\pi^+\pi^-\gamma$ of the eta, and to rare decay modes. Chapter VII is devoted to the position of the physical $\eta(548)$ and the physical $\eta'$ in the $SU_3$ pseudoscalar nonet, and to the experimental evidence which permits the identification of some other physical particles which could be interpreted as an $\eta_1$, $\eta_8$ mixture. The experimental and theoretical problems that are still unresolved, and the possible directions for future work are presented in the conclusions. (L.B.S.)

**21078** PROTON MAGNETIC MOMENT, ITS MEAN RADIUS AND THE AXIAL VECTOR COUPLING CONSTANT CALCULATED BY MEANS OF A SIMPLE MODEL FOR BARYONS. Radescu, E. E.; Corciovei, A. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys., 13: 847-56(1968).

The proton magnetic moment, its mean radius and the axial vector coupling constant in neutron beta decay are calculated in the quasi independent quark model and an exact solution is found for the case of a finite value M of the free quark mass. The dependence of the results on M is studied. (auth)

**21079** NUCLEON ELECTROMAGNETIC FORM FACTORS: EVIDENCE FOR $q^{-4}$ DEPENDENCE. Massam, T.; Zichichi, A. (CERN, Geneva. Univ., Bologna. Istituto Nazionale di Fisica Nucleare, Bologna). Nuovo Cim., Lett., 1: 387-90(Mar. 1, 1969).

A model of the nucleon electromagnetic form factors are previously proposed, which gave a simple explanation of the $q^{-4}$ dependence of the form factors observed in the momentum-transfer region ($q^2 \lesssim 5$ (GeV/c)$^2$). The model is used to analyze more recent data on electron-nucleon scattering. The analysis of the high-momentum-transfer data obtained at Stanford gives evidence for a further $q^{-2}$ dependence in the nucleon electromagnetic form factors, the total dependence being therefore $q^{-6}$. The possibility that this $q^{-2}$ dependence is due to the heavy photon is discussed. (L.B.S.)

## Weak

*Refer also to abstracts 21076 and 21078.*

**21080** SU(3) SYMMETRY BREAKING IN SEMILEPTONIC DECAYS. Pandit, L. K.; Rajasekaran, G. (Tata Inst. of Fundamental Research, Bombay). Nucl. Phys., B9: 531-6(1969).

The first-order SU(3) symmetry breaking in semi-leptonic decays is studied by use of the techniques of equal time commutators. The correction for the baryon axial-vector decay constants is related to that for the strong derivative coupling constants of pseudoscalar meson-baryon interaction. It is further found that the $K_{l2}$ and $\pi_{l2}$ decay constants remain unrenormalized so that $f_K = f_\pi$. (auth)

**21081** SUM RULES FOR WEAK RADIATIVE DECAYS OF PSEUDOSCALAR MESONS AND THE RATIO $F_K/F_\pi$. Lai, C. S. (Indiana Univ., Bloomington). Nucl. Phys., B9: 521-30(1969).

By considering the matrix elements for weak radiative decays of $\pi$ and K mesons, a set of sum rules involving the leptonic decay amplitudes $F_\pi$ and $F_K$ is obtained. Solving the sum rules with Weinberg's sum rule $(g_{A_1}^2/m_{A_1}^2) + F_\pi^2 = (g_{K_A}^2/m_{K_A}^2) + F_K^2$, the ratio $F_K/F_\pi$ is expressible in terms of $A_1$, $K_A$, $\pi$ and K meson masses and the axial-vector meson decay parameters $\delta_{A_1}$ and $\delta_{K_A}$. In a soft-meson limit where $\delta_{A_1} = \delta_{K_A} = -2.0$, the KSRF relation and the ratio $F_K/F_\pi = 1 + \frac{1}{4}(m_K^2/m_{K_A}^2) = 1.04$ are obtained. For the more physical values of $\delta_{A_1}$ and $\delta_{K_A}$, for example at $\delta_{A_1} = -0.8$ and $\delta_{K_A} = -1.4$, the ratio $F_K/F_\pi$ is found to be $F_K/F_\pi = 1.23$. The decay widths of $A_1^+ \to \pi^+ + \gamma$ and $K_A^+ \to K^+ + \gamma$ are also obtained in the present treatment. (auth)

**21082** FOUR-BODY SEMILEPTONIC DECAYS OF HYPERONS. Brene, N. (Univ. of Copenhagen); Kraemmer, A. B.; Vilhjalmsson, T. Nucl. Phys., B9: 543-8(1969).

The rates of four-body semileptonic hyperon decays are calculated, using Cabibbo theory and current-algebra techniques. Observation of such decays cannot be expected until the number of observed hyperons has increased by a factor 10–100. The corrections to the pure current-algebra approach are found to be considerable. (auth)

**21083** WEAK DECAYS OF HADRONS (CP-CONSERVING PART). Stech, B. Lectures given at the Neils Bohr Institute and NORDITA, Copenhagen. Copenhagen, NORDITA, 1968. 60p.

The discussion of weak decays of hadrons covers the general theory, semileptonic decays, sum rules and soft pion calculations, nonleptonic decays, and octet dominance in the structure of weak interactions. (J.F.P.)

**21084** ANALYSIS OF DIVERGENCES IN A NEUTRAL-SPIN-1-MESON THEORY WITH PARITY-NONCONSERVING INTERACTIONS. Lee, T. D. (CERN, Geneva). Nuovo Cim., 59A: 579-98(Feb. 21, 1969).

The unrenormalizable theory of the neutral spin-1 meson with a parity-nonconserving interaction is analyzed. The formal series expansion of any transition amplitude in powers of the coupling constant g can be written as, lowest-order expression $\times \{1 + \Sigma A_n(g^2\Lambda^2)^n + \Sigma B_n g^2(\ln\Lambda^2)(g^2\Lambda^2)^{n-1} + \Sigma C_n g^2(g^2\Lambda^2)^{n-1} + \ldots\}$, where $\Lambda$ is the four-momentum cut-off parameter. It is shown that these singular sums can be carried out for arbitrary processes. The most singular sum $\Sigma A_n(g^2\Lambda^2)^n$ of all processes can be completely removed by a single mass renormalization, the next and the third most singular sums, $\Sigma B_n g^2(\ln\Lambda^2)(g^2\Lambda^2)^{n-1}$ and $\Sigma C_n g^2(g^2\Lambda^2)^{n-1}$, of different processes are also related; these can be removed by introducing further renormalization constants. (auth)

**21085** ASSOCIATIVE ALGEBRAIC MODEL FOR WEAK MESON DECAYS. Boehm, A.; Sudarshan, E. C. G. (Syracuse Univ., N. Y.). Nuovo Cim., 60A: 395-400(Apr. 1, 1969).

An algebraic model describing symmetry breaking is applied to the weak meson decay. The suppression of the strangeness-changing weak decay is obtained as a consequence of symmetry breaking. (auth)

**21086** MULTI-NUCLEON STIMULATED DECAY OF HEAVY HYPERFRAGMENTS. Walker, Charles E.; Prowse, D. J. (Univ. of Wyoming, Laramie). Proc. Indian Acad. Sci., Sect. A, 68: 273-6(Nov. 1968).

A computer program which simulates in a Monte Carlo fashion the single nucleon stimulated decay of heavy hypernuclei was designed. Results on the two fast proton frequency confirm the results of Burte et al. that multinucleon stimulation need not be invoked to explain the experimental results. (auth)

**21087** THE RATIO $\eta_{00}/\eta_{+}$ IN CURRENT-CURRENT MODELS. Gronau, M. (Tel-Aviv Univ.). Nuovo Cim., Lett., 1: 509-12 (Apr. 1, 1969).

Current algebra techniques are used to obtain the ratio $\eta_{00}/\eta_{+}$ in $K^0 \to 2\pi$ decay. This ratio is obtained in various current–current models, while checking the validity of the $\Delta I = \frac{1}{2}$ rule for the CP-violating amplitudes. In all the models treated the weak Hamiltonian is constructed from vector and axial vector currents which are assumed to obey the SU(3) × SU(3) algebra. It is concluded that the use of current algebra permits evaluation of the ratio $\eta_{00}/\eta_{+}$ in various current–current models. In theories of neutral currents one is led to the superweak prediction, while theories with charged currents predict either $|\eta_{00}/\eta_{+}| \simeq 2$ or $\eta_{00} = \eta_{+}$. Both predictions are still not excluded by present experiments. (J.F.P.)

**21088** T VIOLATION IN HYPERON $\beta$-DECAY. Marchioro, C. (Univ., Rome); Pugliese, A.; Prosperetti, A. Nuovo Cim., Lett., 1: 473-8(Mar. 21, 1969).

The coefficient of the T-odd correlation among the polarization of the initial hyperon and the momenta of the outgoing electron and neutrino is given in terms of the most general form factors. An estimate of the expected magnitude of this coefficient is attempted on the basis of a previous model. The electromagnetic final-state interaction effect is calculated using a previous method. It is shown that even if it is difficult to detect a T-violating effect in $\Lambda$ or $\Sigma^-$ $\beta$ decays there is a sufficiently wide experimental range in which the presence of such an effect can be unambiguously imputed to the weak interactions and that there is a possibility of testing the existence of second-class currents. (J.F.P.)

**21089** CP VIOLATION AND THE $\Delta S = \Delta Q$ SELECTION RULE. Chela-Flores, J. (London Univ.). Nuovo Cim., Lett., 1: 441-4 (Mar. 21, 1969).

Using the generalized parametrization for the CP-violating phenomena, a relation between the charge asymmetry parameter, the Sachs parameter and the complex CP-violating parameter for $K_L^0$ decay to electrons and positrons is found. (J.F.P.)

## *Strong (General)*

**21090** (IFVE-STF-68-54-K) INTERMEDIATE STATES IN THE t-CHANNEL OF THE REACTION AND RADIUS OF STRONG INTERACTIONS. Logunov, A. A.; Mestvirishvili, M. A.; Nguyen Van Hieu; Khrustalev, O. A. (Gosudarstvennyi Komitet po ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). 1968. 15p. (In Russian). Dep.

It is shown that the connection between the effective radius of the interaction and the position of the singularities nearest to the origin in the t- and u-channels of the reaction makes it possible to estimate the value of the differential cross-section of a number of processes of strong interactions. (auth)

**21091** PADE APPROXIMANTS IN STRONG INTERACTIONS. TWO-BODY PION AND KAON SYSTEMS. Basdevant, J. L.; Bessis, D.; Zinn-Justin, J. (CEN de Saclay, Gif-sur-Yvette, France). Nuovo Cim., 60A: 185-238(Mar. 21, 1969).

The Padé approximants to the S-matrix starting from a formal perturbation series are constructed. Starting with a first-order "germ" the higher-order terms are calculated by repeatedly applying unitarity and crossing in the Mandelstam representation. The germ is chosen to be compatible with crossing and analyticity requirements, and to lead to a nonincreasing number of subtraction constants. Meson–meson scattering is considered in which case the germs are simply constants. Systems involving pions and kaons are studied. In that case, there are only three parameters. Resonances and Regge trajectories are computed. The seven lowest-lying two-body resonances ($\rho$, $K^*(890)$, $\varphi$, $K^*(1420)$, $f_0$, $f_0'$, $A_2$) are obtained within a few percent of their actual masses. Also, the intercepts of the $\rho$ and $f_0$ trajectories agree very well with present estimates. Some degeneracies between channels with different quantum numbers appear and are discussed. The comparison with a pure $\pi$-$\pi$ calculation shows promising improvement. The further extensions of the model are explained to compute meson states, and also baryon–meson and baryon–baryon amplitudes. In the course of this work, many mathematical and practical aspects of Padé approximants and their application to various fields are studied. (auth)

**21092** GRAPHICAL FORM OF DUALITY. Rosner, Jonathan L. (Tel-Aviv Univ., Ramat Aviv, Israel). Phys. Rev. Lett., 22: 689-92(Mar. 31, 1969).

A simple visual form of duality is presented. It can be derived from SU(3) couplings for trajectories and the absence of resonances in most exotic channels, and has many physical implications. (auth)

**21093** EXOTIC MESONS AND BARYONS. Minami, S. (Osaka City Univ.). Nuovo Cim., Lett., 1: 485-7(Apr. 1, 1969).

The exotic resonances are studied from a phenomenological point of view, and a systematic description of these resonances is given. (J.F.P.)

## *Strong (Baryon No. = 0)*

*Refer also to abstracts 21152 and 21172.*

**21094** THE PHYSICS OF SPIN-$\frac{1}{2}$ K-MESONS. Selleri, F. (Univ., Bari, Italy. Istituto Nazionale di Fisica Nucleare, Bari, Italy. Univ. of Notre Dame, Ind.). Nuovo Cim., 60A: 291-320 (Mar. 21, 1969).

A recently proposed model of elementary particles in which the K-meson has spin $\frac{1}{2}$ and decays, without conserving angular momentum, to states having $J = 0$ and $J = 1$ is compared with a certain number of empirical facts. The definition of short- and long-lived $K^0$'s is discussed and that the spontaneous decay $K_L \to \pi\pi$ can take place without violating CP-invariance. The $\varphi$-mesons are shown not to decay to $K_1^0K_1^0$ as a consequence of C-invariance, as in the usual scheme, in agreement with experiments. For the same reason $\bar{p}p$ annihilations at rest into $K_1^0K_1^0$ from the $^3S_1$ state are forbidden. The decay of several resonances which can go either to $K\bar{K}$ or to $K\pi$ is discussed and it is shown, in particular, that the $K^*(890)$ must be attributed $J = 3/2$. A long-standing problem of interpretation of X-ray emission from K-mesic atoms is resolved in our model. The 1690 MeV maximum in the cross section for the process $\pi^-p \to K^0\Lambda$ can be attributed to a P-wave final state while in the traditional scheme one has to attribute it, rather unnaturally, to D and F waves. The decays of the K-meson are discussed. It is shown, in particular, that $K_L^0 \to l^+l^-$ is CP-forbidden to the lowest order and that the present upper limits for the decays $K^+ \to \pi^+\gamma$, $\pi^+l^+l^-$ are just above the expected rates. (auth)

**21095** MESON–MESON SCATTERING LENGTHS FROM CHIRAL $SU_3 \times SU_3$. Isham, C. J.; Patani, A. A. (Imperial Coll. of Science and Tech., London). Nuovo Cim., 60A: 255-62 (Mar. 21, 1969).

Using meson transformations under chiral $SU_3 \times SU_3$ derived from general schemes, covariant derivatives are calculated within the framework of the tree approximation. These are used to find meson–meson scattering lengths. (auth)

**21096** LARGE-ANGLE ELASTIC SCATTERING AT HIGH ENERGIES AND THE QUARK MODEL. Bialas, A. (Jagellonian Univ., Krakow. Inst. of Nuclear Physics, Krakow); Czyzewski, O.; Zalewski, K. Acta Phys. Pol., 35: 447-51(Mar. 1969).

A quark model is proposed for the large angle elastic scattering of elementary particles. The model explains the main features of the baryon–baryon and baryon–antibaryon scattering. (auth)

**21097** DECAYS OF THE $\omega$, $\eta$, AND $A_2$ MESONS IN THE VENEZIANO MODEL. Goldberg, H.; Srivastava, Y. (Northeastern Univ., Boston). Phys. Rev. Lett., 22: 749-51(Apr. 7, 1969).

By considering the decay reactions $\omega \to 3\pi$ and $\eta \to \pi + \pi + \gamma$ within the framework of the Veneziano model and the $\rho$ dominance of the isovector electric current, certain coupling constants are fixed and zero parameter relations among others can be obtained. (auth)

**21098** BOSON RESONANCES. Romano, A. (Univ., Bari, Italy). Nuovo Cim., Suppl., 6: 602-36(1968). (In Italian).

A review is made of boson resonances and the experimental results which have contributed to the clarification of some theoretical problems are discussed. The criterion used to evaluate the success of the argument is the classification scheme of the boson resonance according to the quark model. This classification scheme is outlined, and then the experimental data are given and analyzed. (J.S.R.)

**21099** PARITY CONSTRAINTS IN THE VENEZIANO MODEL. Freund, P. G. O.; Schonberg, E. (Univ. of Chicago). Phys. Lett., 28B: 601-2(Mar. 3, 1969).

It is shown that to avoid parity doublets, higher terms must be included in a Veneziano type model for scattering or reaction processes involving two or more particles with spin. Superconvergence relations and chiral constraints are discussed. (auth)

**21100** THE $\omega\rho$-MULTIPION VERTEX IN CHIRAL DYNAMICS. Banyai, L.; Rittenberg, V. (Inst. of Physics, Bucharest). Nuovo Cim., Lett., 1: 459-61(Mar. 21, 1969).

An expression for the $\omega\rho\pi$ Lagrangian is given. It is assumed that this Lagrangian is an (N/2,N/2) chiral tensor. (J.F.P.)

**21101** $\pi\pi$ SCATTERING LENGTHS, CURRENT ALGEBRA, AND THE VENEZIANO MODEL. Osborn, H. (Queen Mary Coll., London). Nuovo Cim., Lett., 1: 513-18(Apr. 1, 1969).

Various aspects of the Lovelace–Veneziano representation for the $\pi\pi$ scattering amplitude and its connections with current algebra are clarified. (J.F.P.)

## *Strong (Baryon No. = 1)*

*Refer also to abstracts 21078, 21096, and 21131.*

**21102** REACTIONS PRODUCING THREE FINAL PARTICLES AND COMPARISON OF THE DOUBLE REGGE POLE MODEL WITH SOME EXPERIMENTAL DATA. Ratti, Sergio (Istituto di Fisica, Milan. Istituto Nazionale di Fisica Nucleare, Milan). Rend. Semin. Mat. Fis. Milano, 38: 77-111(1968).

An analysis is presented of some experimental data on reactions produced by $\pi^-p$ collisions at 11 GeV/c and leading to two

final particles and a resonance, in terms of multiperipheral models, in particular the double Regge pole model. (auth)

**21103** A METHOD FOR THE DETERMINATION OF THE SPIN AND PARITY OF A RESONANCE THROUGH SPIN-ROTATION PARAMETER MEASUREMENTS. Toernqvist, Nils A. (CERN, Geneva). Nucl. Phys., B9: 467-80(1969).

A simple graphical method for studying polarization phenomena is presented. It provides a new method for the determination of the spin and parity of a resonance formed in the reactions $\pi N \to \pi N$, $\pi N \to K\Lambda(\Sigma)$, $KN \to KN$ and $KN \to \pi\Lambda(\Sigma)$. This method of spin-parity determination requires measurements of spin-rotation parameters, and is based on the observation that the spin and parity of the dominating partial wave are simply related to the number of times and the direction the final polarization vector rotates, when the scattering angle is varied from 0 to 180°. This spin-parity determination would be independent of corresponding determinations using angular distributions. Apart from the spin-parity determination, the graphical technique is useful for a compact description of spin effects in terms of directly observable quantities. The method is applied and tested by plotting predictions of $\pi N \to \pi N$ phase-shift analysis. (auth)

**21104** TEST OF A RELATIVISTIC MANY-CHANNEL RESONANCE FORMULA. Brunila, Tomas (CERN, Geneva); Roos, Matts; Pisut, Jan. Nucl. Phys., B9: 461-6(1969).

A relativistic many-channel resonance formula for the $\rho$ meson, proposed recently by Ball and Parkinson, is tested on a compilation of experimental data. It is shown that the formula describes well the behavior of the phase shift $\delta_1^1$ near the $\rho$ resonance. Ball and Parkinson argue that the $N\bar{N}$, $\pi\omega$ and $K^*\bar{K}$ channels are decisive for the dynamical origin of the $\rho$ meson. It is found that the shape of the $\rho$ resonance in the $\pi\pi$ channel is given mainly by the coupling of the $\rho$ meson to the $\pi\pi$ channel. However, the $\pi\pi$ channel alone cannot reproduce the shape satisfactorily, and it is necessary to take one or two additional channels into consideration [$N\bar{N}(\pm)$, $\pi\omega$ or $K^*\bar{K}$]. The $\rho$ meson parameters $M_{\rho^-} = 767.6 \pm 1.7$ MeV, $\Gamma_\rho = 152 \pm 18$ MeV are found in agreement with previous results. (auth)

**21105** O(3,1) SYMMETRY AND KN CHARGE EXCHANGE REACTIONS. Samiullah, M.; Rao, A. Srinivas (Osmania Univ., Hyderabad, India). Nucl. Phys., B9: 514-20(1969).

The high-energy behavior of the KN charge exchange reactions $K^+n \to K^0p$ and $K^-p \to K^0n$ is analysed within the context of the O(3,1) symmetry formalism. A good fit for the experimental data is obtained by using the $\rho$, $\rho'$ and $A_2$ trajectories with the assumptions that the $\rho$ and $A_2$ trajectories are degenerate and that the $\rho$ trajectory is given in terms of the $\rho$ trajectory by the relation $\alpha_{\rho'} = \alpha_{\rho-1}$. (auth)

**21106** VECTOR MESON PRODUCTION AT HIGH ENERGIES AND THE QUARK MODEL. Bialas, A. (Jagellonian Univ., Krakow); Eskreys, A. Acta Phys. Pol., 35: 441-6(Mar. 1969).

A comparison of the predictions of the quark model with existing experimental data on the vector meson production is presented. (auth)

**21107** POMERANCHUKON EXCHANGE PLUS DIRECT-CHANNEL RESONANCES AS A MODEL TO DESCRIBE THE FORWARD DIFFRACTION PEAK IN PION–NUCLEON SCATTERING. Dikmen, F. Ned (Univ. of Arizona, Tucson). Phys. Rev. Lett., 22: 622-5(Mar. 24, 1969).

It is shown that the t-channel Pomeranchukon with slope $\alpha' = 0.7^{+0.16}_{-0.16}$ plus s-channel resonances provide a good model for the description of near forward pion–nucleon elastic scattering in the range 1.00 to 20 BeV/c. (auth)

**21108** REGGE-POLE MODELS FOR KAON–NUCLEON SCATTERING. Dass, G. V.; Michael, C.; Phillips, R. J. N. (Rutherford Lab., Chilton, Eng.). Nucl. Phys., B9: 549-67(1969).

A fresh analysis of high energy kaon-nucleon scattering is made, in terms of P, P', $\omega$, $\omega'$, $\rho$ and $A_2$ Regge poles, in the range $0 \leq -t \leq 1$ (GeV/c)$^2$. High energy data are supplemented by information extracted from low-energy amplitudes, through finite energy sum rules. Within this framework, various alternative models are constructed. Predictions are made for $K^+p$ and $K^-p$ polarization, and for the regeneration cross section $K_2^0 + p \to K_1^0 + p$. (auth)

**21109** E-MESON AND MESON–BARYON SCATTERING IN BROKEN $SU_W(6)$. Zaslavskii, A. N.; Tydor, V. (Joint Inst. for Nuclear Research, Dubna, USSR). Acta Phys. Pol., 35: 373-80 (Mar. 1969). (In Russian).

Data on amplitude disturbance of $SU_W(6)$ symmetry in meson–baryon collisions were analyzed. It was found that the obtained ratios for the cross sections of the processes are in agreement with experimental data. The broken symmetry of $SU_W(6)$ indicated that the ninth pseudoscalar meson E(1420) should be produced as frequently as $\pi$ meson. (tr-auth)

**21110** DISPERSION SUM RULES AND ROTATION OF POLARIZATION IN PION–NUCLEON SCATTERING AT HIGH ENERGIES. Aznauryan, I. G.; Solov'ev, L. D. (Inst. for High Energy Physics, Serpukhov, USSR). Phys. Lett., 28B: 597-9(Mar. 3, 1969).

The pion-nucleon scattering amplitude $B^{(+)}(\nu,t)$ at energies $\nu \gtrsim 5$ GeV and momentum transfer $|t| \lesssim 0.3$ (GeV/c)$^2$ is obtained using dispersion sum rules and the Regge pole model. The rotation of polarization in $\pi^+p$-scattering at high energies is predicted. (auth)

**21111** BARYON RESONANCES. Giacomelli, G. (Univ., Bologna. Istituto Nazionale di Fisica Nucleare, Bologna). Nuovo Cim., Suppl., 6: 517-51(1968). (In Italian).

The data obtained in the past few years on the formation (the presence of a resonance is shown by a peak or a structure in a cross section measured as a function of the energy) and production (the presence of a resonance is shown as a peak in the effective mass of two or more particles) experiments are summarized. The baryon resonance classification schemes presently in use are discussed. It is shown that too little is known of the properties of resonances to be able to establish with certainty which of these classifications schemes are valid. (J.S.R.)

**21112** PRODUCTION MECHANISMS IN $\pi$,K NUCLEON REACTIONS. Focardi, S. (Univ., Bologna. Istituto Nazionale di Fisica Nucleare, Bologna). Nuovo Cim., Suppl., 6: 552-60(1968). (In Italian).

Experimental results obtained on $\pi^+$-nucleon reactions, $\pi^-$-nucleon reactions, $K^+$-nucleon reactions, and $K^-$-nucleon reactions were summarized and compared with current theories. It was concluded that none of the models can explain the experimental data satisfactorily. The OPE model with form factors requires that the function $f(\Delta^2)$ vary with energy in order to explain the experimental data. The OPE model cannot explain the experimental values of the density matrix elements. The OPEA model explains in general (but not always) the increase of the density matrix elements with variation of $\Delta^2$, but is incapable of predicting the values of the total and differential production collision cross sections. The models with exchange of vector mesons have a dependence of the energy on the theoretical cross section in sharp contrast with the increase of the experimental cross section. (J.S.R.)

**21113** SYSTEMATIC TEST OF THE SOFT-MESON THEOREMS AND OF A THEORY OF SU(3) ⊗ SU(3) SYMMETRY BREAKING. von Hippel, Frank (Stanford Univ., Calif.); Kim, Jae Kwan. Contracts F44620-68-C-0075; AT(30-1)-2752. Phys. Rev. Lett., 22: 740-4(Apr. 7, 1969).

A systematic test is made of soft-meson theorem predictions for both elastic and inelastic P-B threshold scattering amplitudes. The predictions are obtained by using an extrapolation procedure developed by Fubini and Furlan and by the authors. The results are in reasonable agreement with a theory of SU(3) ⊗ SU(3)-symmetry breaking proposed recently by Gell-Mann, Oakes, and Renner. (auth)

**21114** INFORMATION ABOUT CURRENT-DIVERGENCE ALGEBRA FROM PION–BARYON SCATTERING. Chan, C. H.; Meiere, F. T. (Purdue Univ., Lafayette, Ind.). Phys. Rev. Lett., 22: 737-40(Apr. 7, 1969).

It is shown that the connection between even scattering lengths and $\sigma$ terms of current algebra depends strongly upon dynamics. The $\sigma$ terms for $\pi\Lambda$ and $\pi\Sigma$ scattering are evaluated and shown to be consistent with a model algebra of current divergences in which the SU(3)-symmetry breaking parameter is not small. (auth)

**21115** THE ROLE OF THE ONE-BARYON EXCHANGE MODEL IN Y* PRODUCTION. Saxena, A. B.; Agarwal, B. K.; Singh, C. P. (Allahabad Univ., India). Nuovo Cim., 60A: 401-4(Apr. 1, 1969).

One-particle exchange diagrams were used to explain the symmetry due to forward as well as backward peakings in the angular distributions of Y* production. (auth)

**21116** CONSTRAINTS ON REGGE-POLE PARAMETERS FROM A NEW FAMILY OF DISPERSION SUM RULES. Lusignoli, M. (Univ., Aquila, Italy. Univ., Rome); Restignoli, M.; Violini, G. Nuovo Cim., Lett., 1: 479-83(Mar. 21, 1969).

It is shown that one can obtain a family of sum rules for the Regge pole parameters, using a slightly modified previous approach. These new sum rules are applied to the forward $\pi$ N scattering. (auth)

**21117** SUPERCONVERGENCE AND $Y_1^*(1385)BP$ COUPLINGS. Seth, V. P.; Agarwal, B. K. (Allahabad Univ., India). Nuovo Cim., Lett., 1: 465-6(Mar. 21, 1969).

The process $\bar{K} + N \to K + \Xi$ is considered, and a nontrivial superconvergent sum rule is written for the amplitude $B^{I,t=0}$. This sum rule is tested by taking contributions from the low-lying inter-

mediate states $\Lambda$, $\Sigma$, and $Y_1^*(1385)$. It is shown that the assumptions regarding the asymptotic behavior derived from Regge pole theory and saturation by a finite number of intermediate states are reasonable. (J.F.P.)

**21118** $\Sigma K^*$ PRODUCTION IN THE RESCATTERING MODEL. Agarwal, B. K.; Singh, C. P. (Allahabad Univ., India). Nuovo Cim., 60A: 429-36(Apr. 1, 1969).

In view of the pronounced failure of the one-particle exchange model in explaining the production angular distributions in the processes $\pi^- p \to \Sigma^- K^{*+}$ and $\pi^- p \to \Sigma^0 K^{*0}$, the possibility of explaining the observed data by assuming dominant absorptive contributions coming from the rescattering square diagrams has been explored. It is found that if these processes are considered as two-step processes and the angular distributions of the real intermediate particles in the s-channel is corrected by means of a suitable form factor, the resulting production angular distributions of the final-state particles are in agreement with the observed data. (auth)

**21119** UNIVERSALITY OF RHO-MESON COUPLING AND SUM RULES FOR PION SCATTERING ON HADRONS. Banerjee, H.; Dutta-Roy, B.; Mallik, S. (Saha Inst. of Nuclear Physics, Calcutta). Nuovo Cim., Lett., 1: 436-40(Mar. 21, 1969).

Previous procedure and assumptions are used for pion scattering on K, $\Xi$, and $\Sigma$. The sum rules found relate the $\rho$–hadron coupling constants to the parameters of the direct-channel singularities. In the $\pi K$ sector the sum rule directly gives a relation between the widths of the $K^*$ and $\rho$ mesons. In the $\pi\Xi$ and $\pi\Sigma$ sectors two sum rules are obtained for the mixing parameter $\alpha \equiv F/(F + D)$ for $PB\bar{B}$ coupling. Both these sum rules are consistent with the value $\alpha \approx 0.4$. (J.F.P.)

**21120** AVOIDANCE OF "DOUBLE COUNTING" AND ASYMMETRY IN THE DALITZ PLOT. Fraser, G. (Tel Aviv Univ., Israel). Nuovo Cim., Lett., 1: 367-8(Mar. 1, 1969).

It is suggested that all double counting can be avoided if amplitudes are written as a sum of only Pomeranchuk exchanges and finite-energy s-channel resonances. The allowed diagrams for the process $\pi^+ + p \to \pi^+ + \pi^0 + p$ are shown. The marked asymmetry of the $\pi^+ + p \to \pi^+ + \pi^0 + p$ Dalitz plot is explained by the acceptance of only Pomeranchuk exchanges. (L.B.S.)

**21121** DETERMINATION OF THE SLOPE OF THE POMERANCHUK TRAJECTORY FROM A PHENOMENOLOGICAL "MULTI-VENEZIANO" MODEL. Roberts, R. G. (CERN, Geneva). Nuovo Cim., Lett., 1: 364-6(Mar. 1, 1969).

A phenomenological generalization of the Veneziano model is used to study multiparticle production and is applied to the reactions $\pi N \to (n-1)\pi N$. The slope of the Pomeranchuk trajectory is calculated and is found to be consistent with almost complete absence of shrinkage of the diffraction peak in $\pi N$ scattering. It is concluded that in the multi-Veneziano model the Pomeranchuk trajectory is not a Regge trajectory in the usual sense, but is simply a convenient way of parametrizing diffraction scattering which is entirely the shadow of inelastic scattering. (L.B.S.)

**21122** $SU_3$ CONTINUOUS-MOMENT SUM RULES FOR MESON–BARYON SCATTERING. Garcia, A.; Masperi, L. (CNEA, Bariloche, Italy. Istituto de Fisica Balseiro, Bariloche, Italy). Nuovo Cim., Lett., 1: 379-83(Mar. 1, 1969).

The possibility of generating t-channel Regge poles is tested by saturating continuous-moment sum rules for meson-baryon forward scattering within SU(3) with narrow-width resonances. It is found that Pomeranchukon exchange can only be reproduced by the inclusion of an s-channel background, which gives a dominant contribution to the crossed singlet amplitude sum rule. Approximate superconvergence is obtained for invariant amplitudes which do not correspond to known particle exchanges. The asymptotic relation $A'(\nu) = \nu B(\nu)$ is found to hold for even-signature amplitudes. (L.B.S.)

## *Strong (Baryon No. ≥ 2)*

*Refer also to abstracts 19662 and 21096.*

**21123** (JINR–E2-4286) KINEMATICS AND REGGE DYNAMICS OF QUASI-TWO-BODY N–N INTERACTIONS. Doan Nhuong; Muradyan, R. M. (Joint Inst. for Nuclear Research, Dubna (USSR) Lab. of Theoretical Physics). 1969. 27p. Dep.

The quasi-two-body nucleon-nucleon reactions $N + N \to N + \Delta(1236, 3/2^+)$ $N + N \to N + N^*(1518, 3/2^-)$ $N + N \to N + N'(1470, 1/2^+)$ are considered in the framework of the Regge theory. The conspiracy relations, the threshold and pseudothreshold constraints imposed on the t-channel parity-conserving helicity amplitudes are derived. From the factorization of the Regge-pole amplitudes some information about conspiracy or evasion is obtained. The Regge-pole formulas for the differential cross sections and the spin density matrix elements are given.

**21124** (JINR–P2-4272) SPIN EFFECTS IN THE ELASTIC SCATTERING OF MESONS AND NUCLEONS BY DEUTERONS AT SMALL MOMENTUM TRANSFERS. Tseren, Ch. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). 1969. 10p. (In Russian). Dep.

Spin effects in the elastic scattering of mesons and nucleons by deuterons at small momentum transfers are considered. The amplitudes of free $N\pi$(NN) scattering are presented, and it is assumed that $A_n = A_p$. The corrections of Wilkin and the t-dependence phases of the $\pi$N(NN) amplitude and a contribution of the square of the spin flip amplitudes are neglected in view of their smallness in the region of the dip. An expression for the $(d\sigma/dt)_{\pi d}$ is obtained. In the case when $|a_N| = |\beta_N|$ a similar expression is obtained for $d\sigma/dt$. In such an approximation the introduction of spin variables in the differential cross section does not explain the discrepancy between the theory and the experimental data. Further it is probably necessary to take into account the multiple scattering at least triple scattering, as their contribution may be appreciable in $t_0$. (auth)

**21125** SOME QUALITATIVE ASPECTS OF O(3,1) PARTIAL-WAVE ANALYSIS OF OFF-FORWARD N–N SCATTERING. Nwachuku, C. O. (Univ. of Durham, Eng.). Nucl. Phys., B9: 501-13(1969).

A qualitative analysis of off-forward high energy nucleon–nucleon scattering is made using O(3,1) partial wave expansion together with the extra assumption that the pole amplitude is invariant under $SU(3)_R \otimes SU(3)_L$. Some of the results compare favorably with experiment and with Regge pole theory provided Lorentz poles are admitted with $j_0 = 0$ and $j_0 = 1$. The contrasting features with Regge poles are discussed. (auth)

**21126** HIGHLY INELASTIC pp SCATTERING AND ITS INTERPRETATION. Garelick, D. (Brookhaven National Lab., Upton, N. Y.). Phys. Rev. Lett., 22: 674-7(Mar. 31, 1969).

A plot of inelastic pp scattering cross sections is made in terms of the variable $X_\perp \equiv \frac{1}{4}(\beta_1^* + \beta_3^*)^2 P_\perp^2$, where $\beta_1^*$ and $\beta_3^*$ are the initial and final velocities of the unexcited proton in the center-of-mass system and $P_\perp$ is the perpendicular momentum transfer. This plot suggests that the inelastic cross sections depend only on $X_\perp$ and have for $X_\perp < 0.75$ GeV$^2$ approximately the same $X_\perp$ dependence as does the square root of the elastic pp cross sections. (auth)

**21127** MONTE CARLO CALCULATIONS OF RESIDUAL NUCLEI PRODUCTION IN THICK IRON TARGETS BOMBARDED BY 1- AND 3-GeV PROTONS AND COMPARISON WITH EXPERIMENT. Armstrong, T. W. (Oak Ridge National Lab., Tenn.). J. Geophys. Res., 74: 1361-73(Mar. 15, 1969).

Calculations were carried out for the spatial distribution of certain residual nuclei produced in thick iron targets bombarded by 1- and 3-GeV protons. Direct comparisons with available experimental results are made, and, in general, the agreement is quite good. In addition, the total production of various nuclei in the entire target and the longitudinal variation of the production of several elements are calculated. (auth)

**21128** ON THE INCLUSION OF CONSERVATION LAWS IN ELEMENTARY PROCESSES IN EVALUATIONS OF INTERNAL NUCLEAR CASCADES. Sobolevskii, N. M.; Toneev, V. D. (Joint Inst. for Nuclear Research, Dubna, USSR). Acta Phys. Pol., 35: 367-71(Mar. 1969). (In Russian).

A great deal of difficulty was encountered in simulating inelastic $\pi$N and NN interactions which were made in order to calculate fast particle collisions with atomic nuclei using a cascade model. One of the main difficulties was presented by the demands of great accuracy in calculating the laws of energy and momentum in estimating the elementary process characteristics according to the known experimental angular and energy distribution of generated particles. An analysis was made of the extent of the effect due to a precise estimate of the law of conservation of energy in the equivalent system on the characteristics of an elementary process and on the results obtained for inelastic nucleon–nuclei interactions. (tr-auth)

**21129** HYPERNUCLEI. Danysz, Marian; Pniewski, Jerzy (Univ., Warsaw. Inst. for Nuclear Research, Warsaw). Postepy Fiz., 19: 581-90(1968). (In Polish).

This survey presents the main problems of 15 year studies on hypernuclear physics. Some experimental results and theoretical approaches to the understanding of these results are discussed. New techniques suggested now in this field of research seem to open a possibility of studying hypernuclear spectroscopy, which should help to understand better the $\Lambda$-N interaction. (auth)

**21130** SINGLE REGGE POLE MODEL FOR LARGE ANGLE ELASTIC p–p SCATTERING AT HIGH ENERGIES. Meng, Ta-chung; Zeiler, J. (Freie Univ., Berlin). Z. Phys., 221: 274-80 (1969).

The elastic proton-proton angular distribution at large momentum transfers [$-t \gtrsim 8$ (GeV/c)$^2$] and energies above 10 GeV laboratory momentum can be understood in the framework of a single Regge pole model. (auth)

**21131** RELATIONS BETWEEN HELICITY AMPLITUDES IN HIGH-ENERGY ELASTIC p–p SCATTERING. Neal, H. A.; Young, Bing-lin (Indiana Univ., Bloomington). Nuovo Cim., Lett., 1: 369-74(Mar. 1, 1969).

It is shown that the general features of high-energy pp and $\pi^-$p polarization data can be accounted for by a model which assumes that the dynamics is not strongly helicity dependent. The success of the model suggests that the shape of the polarization curves in pp and $\pi$p scattering at small |t| and large s is determined primarily by kinematics. (L.B.S.)

# Particle Invariance Principles and Symmetries

## General

**21132** (IFVE-STF-68-51-K) THE INFINITESIMAL OPERATORS OF THE REGULAR REPRESENTATION OF THE NONCOMPACT GROUPS OF ROTATION O(p,q). Leznov, A. N. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). 1968. 14p. (In Russian). Dep.

A method for constructing infinitesimal operators of the regular representations of the noncompact group of rotation O(pq) is developed. A prescription for constructing the irreducible representations of the noncompact groups by using a transition to the "limit" representation, which is received from the regular one at infinite values of noncompact parameters is described. (auth)

**21133** (ZFK-130, pp 205-8) PROJECTION OPERATORS AND CLEBSCH-GORDAN COEFFICIENTS FOR THE $SU_3$ GROUP. Asherova, R. M.; Smirnov, Yu. F. (Moscow State Univ. (USSR). Inst. for Nuclear Physics).

The method of calculating Clebsch–Gordon coefficients by using projection operators was applied to the SU(3) group. (J.W.R.)

**21134** AN ELEMENTARY PROOF OF THE PLANCHEREL THEOREM FOR THE CLASSICAL GROUPS. Ruehl, W. (CERN, Geneva). Commun. Math. Phys., 11: 297-302(1969).

It is shown how to reduce the Plancherel theorem to one lemma which is proved by elementary means. (auth)

**21135** SELF-CONJUGATE MULTIPLETS, TCP AND LOCALITY. Fabri, E.; Picasso, L. E. (Univ., Pisa, Italy. Istituto Nazionale di Fisica Nucleare, Pisa, Italy). Nuovo Cim., 60A: 481-93(Apr. 1, 1969).

A classification of the representations to which self-conjugate multiplets may belong is given both in the case of local and nonlocal symmetries. For local symmetries, when the mass of the particles in the multiplet is not zero, and/or when the spin is zero, Carruthers' result is derived. Counterexamples to Carruthers' theorem are given for nonlocal symmetries and for the zero-mass, nonzero-spin local case. Then it is shown that a certain class of nonlocal symmetries (including those for which Carruthers' theorem is violated) can only occur in a theory with noninteracting fields (generalized free fields). (auth)

## Applications (Electromagnetic and Weak)

*Refer also to abstracts 21141 and 21142.*

**21136** (IFVE-STF-68-46-K) CONCERNING KINEMATIC LIMITATIONS ON THE AMPLITUDE OF PHOTOPRODUCTION IN O(4). Zamiralov, V. S.; Shepelev, G. I. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). 1968. 5p. (In Russian). Dep.

The production of pions on the nucleons is considered in the scheme of the O(4) symmetry, proposed by Freedman and Wang. It is shown that the production amplitude vanishes at t = 0 if the mass of the virtual photons equals that of the pion. (auth)

**21137** (KFKI-2/1969) MILLISTRONG C VIOLATION AND $\eta$ DECAY. Frenkel, A.; Marx, G. (Magyar Tudomanyos Akademia Kozponti Fizikai Kutato Intezete, Budapest). 1969. 31p. Dep.

The isospin properties of the /assumed/ millistrong C violation were investigated. The consequences of a $\Delta I = 0$ and $\Delta I = 2$ selection rule are discussed for the $\eta \to \pi^+\pi^0\pi^-$ and $\eta \to \pi^0 e^+ e^-$ decays. If the observed charge asymmetry of the $\eta \to \pi^+\pi^0\pi^-$ is realistic, the C violating $3\pi$ final state is mainly an I = 2 eigenstate, produced by a $\Delta I = 0$ coupling with a constant $g_2 \simeq 10^{-2}$. Since the I = 0 eigenstate is here very much suppressed by the centrifugal barrier, the $\Delta I = 0$ coupling may be much stronger, e.g., $g_0 > 10^{-1}$, limited only by the negative results of the $\eta \to \pi^0 e^+ e^-$ experiments. So the $\Delta I = 0$ dominance of the millistrong C violation, suggested by the indication $|\epsilon| \gg |\epsilon'|$ in the $K^0$ decays, is by no means in contradiction with the observed $\Delta I = 2$ character of the $\eta \to \pi^+\pi^0\pi^-$ asymmetry. The importance of more accurate experiments is emphasized.

**21138** BARYON AND MESON OCTETS, THE $K^0$ MESON DILEMMA AND THE BACH. Lewis, D. T. (Lab. of Government Chemist, London). Chem. Ind. (London), No. 11, 317-20(Mar. 15, 1969).

It is stated that the existence of the forbidden decay of the $K_2^0$ meson, with its violation of CP symmetry, is one of the most inexplicable problems in particle physics, encouraging the suggestion of highly imaginative solutions. A solution is offered on the basis of the "bach-tamaid" theory. (UK)

**21139** UNIFICATION OF EXTERNAL AND INTERNAL MOTIONS WITHIN $SO_{4,1}$ AND POSSIBLE MASS SPLITTING OF $SU_3$ BARYON MULTIPLETS WITHOUT SYMMETRY BREAKING. Vigier, J.-P. (Institut Henri Poincare, Paris). Nuovo Cim., Lett., 1: 445-52(Mar. 21, 1969).

The unification of an external group of motion, E, and an internal symmetry group, I, within a global dynamical group, G, is considered in such a way that the mass splitting within SU(3) multiplets appears without symmetry breaking. It is proposed to take $E = SO(4,1) \times U(1) = g \times U(1)U(1)$ corresponding to the external c.m. field and $G = SO(6,1) \times U(1)$; with the essential requirement that the external SO(4,1) (denoted by g) and a certain subgroup $g' = SO(4,1) \subset SO(6,1)$ are left and right translations of the same SO(4,1); that is, are right and left translations of $SO(4,1) \subset (SO(6,1)$ the SO(6,1) of $G = U(1) \times SO(6,1)$. Weak, strong, and electromagnetic interactions are considered. The mass formula is calculated, and particles are classified in finite irreducible nonunitary representations. (J.F.P.)

## Applications (Strong)

*Refer also to abstract 21139.*

**21140** CONTINUUM CONTRIBUTIONS TO VECTOR-MESON DECAYS. II. BROKEN $U_3$ SYMMETRY. Vaughn, Michael T. (Northeastern Univ., Boston); Wali, Kameshwar C. Phys. Rev., 177: 2199-2205(Jan. 25, 1969).

A model is constructed for estimating the continuum contributions to the propagators of the vector mesons $\rho$, $\omega$, and $\phi$. With this model, vector-meson decay rates predicted by a model of octet-broken $U_3$ symmetry are computed based on spectral-function sum rules for the propagators. The model is consistent with experiment, but present experimental accuracy is not sufficient to distinguish clearly between the pole-dominance form of the model and the model with continuum included. (auth)

**21141** PARITY VIOLATION IN ELECTROMAGNETIC AND STRONG INTERACTION PROCESSES. Hamilton, W. D. (Univ. of Sussex, Brighton, Eng.). Progr. Nucl. Phys., 10: 1-75(1969).

The current position in parity violation studies is reviewed, after a brief outline of the origin of the parity violating interaction and the different forms of internucleon potential which may be used to describe it. The conditions which are necessary in order to observe parity violation are considered and the bases outlined on which experimental methods are founded. The current experimental situation is described, together with detailed results. Some possible sources of error, and particularly those associated with magnetic field changes, are briefly discussed, together with the different approaches used in data treatment in order to minimize the effects of short and long term drifts. An extensive bibliography is included. (UK)

**21142** BREAKING OF SU(3) AND PARTIAL CONSERVATION OF VECTOR CURRENTS. Krolikowski, W. (Inst. for Nuclear Research, Warsaw. Univ. of Warsaw). Bull. Acad. Pol. Sci., Ser. Sci. Math. Astron. Phys., 16: 961-3(1968).

The idea was previously proposed by Nambu and Sukurai that some $J^P = 0^+$, $I = \frac{1}{2}$ mesons would be responsible for breaking the SU(3) symmetry and that the mechanism involved would be the partial conservation of the strangeness-changing vector currents. This idea is reformulated in such a way that only $I = \frac{1}{2}$ scalar mesons could spoil the SU(3) symmetry, even if other scalar mesons existed. An expression for the partial conservation of vector currents is postulated in terms of functions which describe the SU(3) multiplets 1, $8_F$, $8_D$, 10, $10^*$, and 27 of some

hypothetic scalar mesons and matrices denoting the Clebsch-Gordon coefficients of the SU(3) group. The formalism is applied to the $K^- \to \pi^0$ and $\Lambda \to p$ transitions. (L.B.S.)

**21143** MESONS IN THE HIGHER-SYMMETRY REGGEIZATION. Mahanta, P. (Imperial Coll. of Science and Tech., London). Nuovo Cim., 60A: 383-94(Apr. 1, 1969).

Classification of the mesic states into the $SU_3$ multiplets occurring in the first two members of the most degenerate Feynman series is made. On the basis of the physical masses of the particles, a simple mass formula for the $SU_3$ multiplets in an $SU_6$ representation is suggested. (auth)

**21144** ASYMPTOTIC THEOREMS FROM ANALYTICITY AND $SU_2$ SYMMETRY. Nenciu, G. (Inst. of Atomic Physics, Bucharest). Rev. Roum. Phys., 13: 869-78(1968).

Using the phase representation, the Bessis and Kinoshita power behavior criterion is generalized to crossing nonsymmetric amplitudes. Combining $SU_2$ symmetry and the asymptotic relations given by analyticity, a new asymptotic relation for $\pi-N$ scattering is obtained. (auth)

# Field Theories

## *Quantum Field Theory*

*Refer also to abstract 21170.*

**21145** (JINR-E2-4189) PARTIAL SYMMETRY, EQUIVALENCE THEOREMS, AND CALCULATION OF HIGHER ORDERS IN NONRENORMALIZABLE FIELD THEORIES. Filippov, A. T. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1968. 19p. Dep.

Methods of calculations of higher-order corrections in nonrenormalizable field theories are critiqually investigated. The inconsistency of perturbation theory (with a cut-off on the unitary limit) is strongly suggested and alternative methods are discussed. The nonrenormalizable theories with partial symmetries prove to be of particular interest. For these theories a new method based on the extensive use of the approximate Ward-type identities is developed. (auth)

**21146** (JINR-P2-4115) COVARIANT STRUCTURE OF THE TWO-POINT FUNCTION. Oksak, A. I.; Todorov, I. T. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Theoretical Physics). 1968. 35p. (In Russian). Dep.

The spectral representation of the two-point function for arbitrary fields proposed recently is rigorously proved and analyzed. The problem is treated in momentum space where the covariant structure is simpler because of the spectrum conditions. For finite-component fields the general covariant structure is found in coordinate space too and is applied to the definition of time-ordered Green functions for arbitrary spin. The decomposition of the two-point function into kernels of definite spin is proved and a necessary and sufficient condition for the growth of the coefficients of this decomposition is given. The formalism of homogeneous distributions in two-dimensional complex space is used throughout. (auth)

**21147** QUANTUM THEORY OF SCALAR FIELD IN DE SITTER SPACE-TIME. Chernikov, N. A.; Tagirov, E. A. (Joint Inst. for Nuclear Research, Dubna, USSR). Ann. Inst. Henri Poincare, Sect. A, 9: 109-41(1968).

The quantum theory of scalar field is constructed in the de Sitter spherical world. The field equation in a Riemannian space-time is chosen in the form $\Box\varphi + 1/6\, R\varphi + (mc/\hbar)^2\, \varphi = 0$ owing to its conformal invarance for $m = 0$. In the de Sitter world the conserved quantities are obtained which correspond to the isometric and conformal transformations. The Fock representations with the cyclic vector which is invariant under isometries are shown to form an one-parametric family. They are inequivalent for different values of the parameter. However, its single value is picked out by the requirement for motion to be quasiclassic for large values of square of space momentum. Then the basis vectors of the Fock representation can be interpreted as the states with definite number of particles. For $m = 0$ this result can also be obtained from the condition of conformal invariance. It is proved that the above requirement for motion to be quasiclassic cannot be satisfied at all in the theory with equation $\Box\varphi + (mc/\hbar)^2\, \varphi = 0$. (auth)

**21148** CONSERVATION OF THE NUMBER OF FERMIONS. Ohnuki, Y. (Nagoya Univ., Japan); Kamefuchi, S. Nucl. Phys., B9: 537-42(1969).

Some kinds of composite particles consisting of paraparticles do not obey the ordinary parastatistics. It is proposed to call such particles quasi-parabosons or quasi-parafermions according to whether a certain physical quantity, to be called A, takes even or odd values for these particles. It is argued that the total number of fermions, parafermions and quasi-parafermions is absolutely conserved modulo 2 in all reactions. The theoretical importance of the parallelism which exists between the quantity A and angular momentum is emphasized in connection with the spin-statistics theorem. (auth)

**21149** A SIMPLE DERIVATION OF THE NORMALIZATION CONDITION FOR THE BOUND-STATE BETHE-SALPETER WAVE FUNCTION. Smith, C. H. Llewellyn (CERN, Geneva). Nuovo Cim., 60A: 348-51(Mar. 21, 1969).

A simple derivation is given for the well-known normalization condition for the Bethe-Salpeter wave function. (auth)

**21150** INTERACTING LOCAL QUANTUM FIELDS DESCRIBING MANY MASSES AND SPINS. Bierter, W.; Bitar, K. M. (Univ. of California, Berkeley). Nuovo Cim., 60A: 330-8(Mar. 21, 1969).

The possible restrictions of locality on interacting quantum fields are investigated, which create or destroy many-particle states with different masses and spins. First the vacuum expectation value of the commutator (or anticommutator) of two Heisenberg fields is examined. Demanding that these fields transform as representations of the homogeneous Lorentz group and using the CPT-theorem it is proved that locality gives no relations between the different spectral functions, and the relations between the masses as functions of the spin are the same as those found by Abarbanel and Frishman for free fields. Then with the help of the Yang-Feldman equations the problem is examined in perturbation theory. It is found that demanding locality at each order in perturbation theory in a manner consistent with the general results found above imposes restrictions on the possible forms of these interactions. (auth)

**21151** CURRENT COMMUTATION RELATIONS FOR INTERACTING FIELDS. Trubatch, J. (California State Coll., Los Angeles). Nuovo Cim., 60A: 239-54(Mar. 21, 1969).

A procedure for obtaining the dependence of conserved currents on the fields they generate is developed by imposing gauge invariance on a nonlocal definition of the Lagrangian. This explicit nonclassical field dependence is exhibited for several interactions and shown to be sufficient to yield the necessary equality of the current-current and current-field commutators when interactions with massive fields are considered. (auth)

**21152** SPECTRAL-FUNCTION SUM RULES. Bollini, C. G.; Giambiagi, J. J. (International Atomic Energy Agency, Trieste, Italy). Nuovo Cim., 60A: 339-47(Mar. 21, 1969).

Sum rules for the spectral functions of vector and axial field are obtained from hypotheses on the behavior of vacuum values of the commutators on the cone. The consequences of vector dominance are examined. A discussion is given on the relation between our hypothesis and that of the equality of the unrenormalized masses and coupling constants. The sources of the fields are taken to be the weak vector and axial vector currents. (auth)

**21153** HIGH-ENERGY ELASTIC SCATTERING IN QUANTUM ELECTRODYNAMICS. Cheng, Hung (Massachusetts Inst. of Tech., Cambridge); Wu, Tai Tsun. Phys. Rev. Lett., 22: 666-9 (Mar. 31, 1969).

All two-body, elastic-scattering amplitudes in quantum electrodynamics were examined. Aside from the photon-pole contribution, the amplitude for any elastic process is imaginary and proportional to s in the limit $s \to \infty$ with t held finite. The coefficients of s, to the lowest nonvanishing orders of e, can be expressed simply in terms of "impact factors." The results contradict both the Regge-pole model and the droplet model in their most straightforward interpretations. (auth)

**21154** EXPERIMENTAL TEST OF QUANTUM ELECTRODYNAMICS BY MUON BREMSSTRAHLUNG. Liberman, A. D. (Harvard Univ., Cambridge, Mass.); Hoffman, C. M.; Engels, E. Jr.; Imrie, D. C.; Innocenti, P. G.; Wilson, Richard; Zajde, C.; Blanpied, W. A.; Stairs, D. G.; Drickey, D. J. Phys. Rev. Lett., 22: 663-6(Mar. 31, 1969).

Muon bremsstrahlung of 9- to 13-GeV/c muons was measured by using a carbon-plate spark chamber as a target. Results in the region of invariant four-momenta of the recoil muon-photon system 200-650 MeV/c are consistent with the predictions of quantum electrodynamics. (auth)

**21155** ABELIAN FIELDS OF SPECIAL TYPE. Garczynski, W.; Lopuszanski, J. T. (Univ. of Wroclaw, Inst. of Low Temperature Physics and Structural Research, Wroclaw). Acta Phys. Pol., 35: 407-12(Mar. 1969).

It is proved that the abelian Wightman field A(x) is a polynomial in x variables. Some natural conditions are indicated under which this polynomial is a constant or vanishes. (auth)

**21156** STATIC MAXWELL–EINSTEIN–KLEIN–GORDON FIELDS. De, N. (Jadavpur Univ., India). Acta Phys. Pol., 35: 363-6(Mar. 1969).

The existence of the stationary s state of matter field generating the most general statical metric and electrostatic fields is considered. The system of equations is seen to be determinate, but if the Weyl–Majumder between $g_{44}$ and the electrostatic potential is assumed the system of equations becomes over determinate and it readily reduces to a determinate one if the mass parameter equals the charge parameter in magnitude. Further, if the matter is at rest the Weyl–Majumder condition is a necessary one and no solution exists unless the mass parameter in magnitude equals the charge parameter i.e., matter cannot be at rest without the mass charge balance. (auth)

**21157** NEW ANTIRELATIVISTIC DYNAMICS. Palacios, Julio (Univ., Madrid). Rev. Real Acad. Cien. Exact., Fis. Nat. Madrid, 62: 69-132(1968). (In Spanish).

The equation $m_W = W/c^2$, which relates energy W with mass $m_W$, is a consequence of Einstein's theory. It is shown that this equation may be obtained from Maxwell's equations without invoking the principle of relativity. The mass of a moving particle, whose mass when at rest is $m_r$, becomes $m = m_r + T/c^2$. From this equation, combined with the principle of conservation of energy, Planck's expression for the kinetic energy $T = m_r c^2/\sqrt{1 - u^2/c^2} - m_r c^2$ is obtained. In a conservative field of force, the relativistic equation of motion $f = m_r\, d/dt\, u/\sqrt{1 - u^2/c^2}$ cannot be applied. Instead, the principle of conservation of energy $d(T + E_p) = 0$ leads to the following equations of motion: Electric field: $-Q(1 - u^2/c^2)^{\frac{1}{2}}$ grad $\phi = m_r\, du/dt$; Magnetic field: $Q(u \Lambda B) = m_r/\sqrt{1 - u^2/c^2} - du/dt$; Gravitation field: $-(1 - u^2/c^2)^{\frac{1}{2}}$ grad $V = du/dt$. It follows from the last equation that the gravitational mass $m_g$ and the inertial mass $m_r$ of a moving particle are related by $m_g = G^{\frac{1}{2}}(1 - u^2/c^2)^{\frac{1}{2}} m_r$. Consequently, the equivalence postulates of Einstein's theory of gravitation must be rejected. (BBB)

**21158** DAMPED SELF-INTERACTION. Reed, Michael (Princeton Univ., N. J.). Commun. Math. Phys., 11: 346-57(1969).

A self-interaction with damped off-diagonal coefficients is used to illustrate techniques for dealing directly with Hamiltonians in strange representations of the canonical commutation relations. (auth)

**21159** A FIELD THEORY DESCRIBING INTERACTING TWO-PARTICLE SUBSYSTEMS. I. GENERAL FORMALISM. Lukierski, J. (Univ. of Wroclaw). Nuovo Cim., 60A: 353-75(Apr. 1, 1969).

The scalar field operator $\phi(x;s)$ describing by means of its one-particle states the s-wave stable bound states and s-wave two-particle states is considered. The complete formulation of local quantum field theory for such a field operator is presented. The generalized LSZ asymptotic condition gives the free asymptotic fields with discrete and continuous mass spectrum. The reduction formulas, defining generalized scattering amplitudes, are introduced. The unitarity condition and the notion of unstable free particles are discussed. The physical interpretation of the generalized scattering amplitudes is given. (auth)

## *Gravitation and General Relativity*

*Refer also to abstract 20653.*

**21160** RELATIVISTISCHE PHYSIK. (KLASSISCHE THEORIE). (Relativistic Physics. (Classical Theory)). Schmutzer, Ernst. Leipzig, B. G. Teubner Verlagsgesellschaft, 1968. 974p. 128,- M.

The discussion of relativity physics covers the geometrical object in n-dimensional space, the general mechanism of field theory and the Noether theorem on the relation of invariance to conservation; tensors, spinors, and bispinors in space–time; the classical fundamental law of physics in space–time; and the use of the Hamilton–Lagrange mechanism and the Noether theorems on the tensorial relation and field equations of physics. Also discussed are the Noether theorem in the case of spinor field theory, special relativistic physics, rigorous solutions for general relativity field equations and their physical consequences, approximate treatment for the general relativistic field equations, and five-dimensional projective field theory. (TSS)

**21161** GENERALIZATION OF THE KALUZA–KLEIN THEORY FOR AN ARBITRARY NON-ABELIAN GAUGE GROUP. Kerner, Ryszard (Univ., Warsaw). Ann. Inst. Henri Poincare, Sect. A, 9: 143-52(1968).

The isomorphism between the Utiyama and the Kaluza–Klein theories of electromagnetism is generalized to the case of a non-abelian semi-simple gauge group. The equations of the nonabelian gauge field are derived from a geometrical least action principle. The interaction between the gravitational and the generalized Yang–Mills field is given explicitly. The equations of motion of a particle in an external field are obtained from the geodetic equation in the principal fibre bundle space. (auth)

**21162** RESTRICTED MOTIONS OF GRAVITATING SPHERES. Taub, A. H. (Univ. of California, Berkeley). Contract AT-(11-1)-34. Ann. Inst. Henri Poincard, Sect. A, 9: 153-78(1968).

Two restricted classes of spherically symmetric time-dependent solutions of the Einstein field equations are discussed. For both of these the source of the gravitational field is a perfect fluid which occupies a limited region of space-time. The first class contains solutions discussed by Thompson and Whitrow, by Bondi and by Bonnor and Faulkes. The second class of solutions are those treated by McVittie. It is shown that McVittie's solutions are a subclass of the first class of solutions and that if an equation of state exists then solutions of the first class satisfy McVittie's similarity requirements. Not all of McVittie's solutions satisfy an equation of state. The solutions of the first class treated by the authors listed above are special in that they have uniform energy density. Various methods are described for determining oscillating as well as collapsing and expanding uniform solutions. It is shown that for an oscillating solution, the outer boundary of the matter is always outside the Schwarzschild radius of the total gravitating mass. (auth)

**21163** SURFACE LAYERS OF MATTER IN GENERAL RELATIVITY. Papapetrou, A.; Hamoui, A. (Institut Henri-Poincare, Paris). Ann. Inst. Henri Poincare, Sect. A, 9: 179-211(1968). (In French).

A general treatment of surface layers in general relativity is presented. Starting from the field equations a number of relations valid for an arbitrary surface layer are derived. The splitting of these relations into components orthogonal and parallel to the hypersurface $\Sigma$, which represents the motion of the surface layer, leads to the 3-dimensional relations obtained previously. A detailed study of spherically symmetric surface layers is given. Restriction is made to the case where there is no other matter than that of the surface layer in which case the metric is Minkowskian inside $\Sigma$. It is further assumed that matter consists of point particles interacting only through their gravitational field (ideal gas). This property is characterized by a relation which constitutes the equation of motion of the layer. A detailed study of the types of motion permitted by this equation shows that there are motions which start or end on the singularity $r = 0$. But there are also motions without any singularity which consist of a contraction from $r = \infty$ to $r = r_{min} \neq 0$, followed by an expansion to $r = \infty$. (auth)

**21164** DISCUSSION OF GRAVITATIONAL FIELD EQUATIONS IN CASE OF A GENERAL SPHERICALLY SYMMETRIC METRIC FORM. Kuchowicz, B. (Univ., Warsaw). Phys. Lett., 28A: 653-4(Feb. 10, 1969).

Exact solutions of the gravitational field equations describing a sphere of fluid at rest in a canonical Schwarzschild coordinate system were obtained previously. One usually applied the method of reducing the problem to that of finding solutions of a differential equation: either a second order homogeneous equation or a first order homogeneous equation. The respective differential equations are given for a generally spherically symmetric metric form. (auth)

**21165** A COMMENT ON THIN SHELLS IN GENERAL RELATIVITY. Horsky, J. (Brno Univ., Czech.). Phys. Lett., 28A: 599(Feb. 10, 1969).

The special type of space-time metric is related to a plane source. (auth)

**21166** ON SPECIAL RELATIVITY. Becker, J. J. Phys. Lett., 28A: 594-5(Feb. 10, 1969).

The correct application of special relativity to the case of a "rotating" disc is given. The effects of gravitation cannot be deduced from the application of special relativity. The definitions of unit time interval and unit space interval are discussed. (auth)

**21167** STUDY OF EMPTY SPACE–TIME WHICH ALLOW A METRIC OF THE KERR TYPE. Mas, Luis (Institut Henri Poincare, Paris). Compt. Rend., Ser. A, B, 268: 441-4(Feb. 17, 1969). (In French).

The Kerr type space–time is studied from a determined reference point and particularly the Killing vectors of these spaces are studied. (tr-auth)

# Scattering Theory

*Refer also to abstract 21029.*

**21168** RISING REGGE TRAJECTORIES AND CROSSING SYMMETRY. Caser, S.; Kaplan, J. M.; Omnes, R. (Laboratoire de Physique Theorique et Hautes Energies, Orsay, France). Nuovo Cim., 59A: 571-8(Feb. 21, 1969).

If there are infinitely rising Regge trajectories, the asymptotic behavior of the Regge-pole terms in the s- and t-channels cannot be compatible with each other in the whole (s,t) plane. Thus the background integral cannot be neglected asymptotically if crossing symmetry is to be valid. As a consequence of this, there does not remain any restriction either on the rate of increase of possible rising Regge trajectories except possibly a lower bound in $\sqrt{s}$ or on the behavior of the residue functions. (auth)

**21169** SELF-CONSISTENT REGGE SINGULARITIES. Halliday, I. G. (Imperial Coll. of Science and Tech., London). Nuovo Cim., 60A: 177-84(Mar. 21, 1969).

A technique is demonstrated that allows one to obtain t-channel Regge singularities that are consistent with the s-channel unitarity equation in a bootstrap theory. At asymptotic s an integral equation is obtained in two variables for essentially a Reggeon-particle scattering "amplitude" depending on a parameter $\gamma$, related to the angular momentum. The poles in $\gamma$ of the solution give us Regge poles self-consistently. If we approximate the kernel of the equation by a separable function then the poles may be explicitly demonstrated. As a second example it is shown how if the Reggeon is a double pole in the l-plane self-consistency is obtained in a calculation of only the leading terms for each intermediate state in the unitarity equation. (auth)

**21170** REGGE BEHAVIOR OF PRODUCTION AMPLITUDES IN A FIELD-THEORY MODEL. Zakrzewski, W. J. (Cambridge Univ., Eng.). Nuovo Cim., 60A: 263-90(Mar. 21, 1969).

Asymptotic properties of a two-to-three amplitude are considered in a field-theory model. The complete high-energy behavior of double Regge-pole exchange is given and its dependence on the variable $\eta$, which corresponds to the angle between the two production planes, is considered. Two triangle graphs are also considered corresponding to the exchange of a double Reggeon together with either an elementary particle or another Reggeon. In all calculations Mellin transforms of the amplitude are used. The results show the expected cut structure with two-dimensional loop integration and they agree with the results obtained using the Gribov approach. Signature is also introduced and it is shown that the results are modified in the usual way. (auth)

**21171** REGGE CUTS, DUALITY, AND EXOTIC RESONANCES. Pinsky, S. (Weizmann Inst. of Science, Rehovoth, Israel). Phys. Rev. Lett., 22: 677-9(Mar. 31, 1969).

It has been suggested that the combination of duality and the Harari–Freund conjecture implies the existence of particles with exotic quantum numbers. It is shown that this conclusion can be avoided if Regge cuts are taken into account. (auth)

**21172** FINITE-ENERGY SUM RULE AND NONLINEARLY RISING REGGE TRAJECTORIES. Mohapatra, R. N. (Univ. of Rochester, N. Y.). Phys. Rev. Lett., 22: 735-7(Apr. 7, 1969).

Demanding the consistency of finite-energy sum rules at high energies, it is predicted that Regge trajectory $\alpha(s)$ increases at large energies as $(s \ln s)^{\frac{1}{4}}$ and the elastic widths of resonances go as $s^{\alpha_t(0)-\frac{1}{2}}/\ln s$ for large s. (auth)

**21173** CONSPIRACY BETWEEN REGGE TRAJECTORIES. Toller, M. (CERN, Geneva). Nuovo Cim., Suppl., 6: 561-74 (1968). (In Italian).

The properties that the Regge trajectories and the residues should have in order that the contribution of a pole, or the sum of the contributions of several poles, be compatible, over a certain energy, with the basic properties of invariance and analyticity of the scattering amplitude are discussed. Two models are derived for these properties. An example is given of the application of these two models. (J.S.R.)

**21174** RISE AND FALL OF REGGE TRAJECTORIES IN POTENTIAL SCATTERING. Aly, H. H. (International Centre for Theoretical Physics, Trieste, Italy); Narayanaswamy, P. Phys. Lett., 28B: 603-5(Mar. 3, 1969).

An outline is given of a model in potential scattering which exhibits indefinitely rising Regge trajectories. The model has built into it several features which one would require in a relativistic theory based on rising trajectories. (auth)

**21175** A PROOF OF THE VALIDITY OF GENERALIZED INTERFERENCE MODELS. Jengo, R. (CERN, Geneva). Phys. Lett., 28B: 606-10(Mar. 3, 1969).

It is shown that, under fairly general hypotheses, the scattering amplitude $A(s,u,t)$ can always be written as $A(s,u,t) = A_1(s,u,t) + A_2(s,u,t) + A_3(s,u,t)$, where for instance $A_1(s,u,t)$ has resonances only in the t channel, and it is such that for $s \to \infty$ at fixed t it has a Regge behavior, whereas it goes to zero faster than any power if $s,t \to \infty$ at fixed u or if $u,t \to \infty$ at fixed s. (auth)

**21176** ASYMPTOTIC BEHAVIOR OF PHASE SHIFTS IN THE SCATTERING BY A CENTRAL POTENTIAL IN THE DIRAC THEORY. Barthelemy, Marie-Claire (Institut Henri Poincare, Paris). Compt. Rend., Ser. A, B, 268: 521-4(Feb. 17, 1969). (In French).

The method of phase shifts and the analytic properties of solutions of a radial Dirac system in the complex momentum plane K was previously studied. Using the same notation, the behavior of the phase shifts is examined when real x is very large. An application is made in the case of an exponential potential. (tr-auth)

**21177** EXTINCT BOUND STATES AND THE EXTENSION OF LEVINSON'S RELATION. Stihi, M. (IAEA, Trieste, Italy). Nuovo Cim., 60A: 376-82(Apr. 1, 1969).

Using the generalized Jost-function formalism in the most general case, when the phase shift at infinity may be even a nonintegral multiple of $\pi$, the extension of Levinson's relation is deduced. This relation reduces to that obtained by Warnock in the $ND^{-1}$ formalism, when a supplementary restriction, that no extinct bound states are present, is imposed. Moreover, a way of improving a practical calculation of the generalized Jost function is given so that the final solution is free of undesirable extinct bound states. (auth)

**21178** ALGEBRA OF OBSERVABLES AND TRIBES OF REGGE POLES. Domokos, G.; Koevesi-Domokos, S. (CERN, Geneva). Nuovo Cim., 60A: 437-66(Apr. 1, 1969).

It is shown that the zero-mass trajectory generating algebra $SL_{2,c}$ can be identified with the algebra spanned by space integrals of appropriate components of vector and axial vector currents. The algebra is then generalized to include internal symmetries, and is found to be a chiral $SU_6 \times SU_6$ algebra. After an analysis of the concept of massless composite-particle states, the commutation relations are saturated by five Lorentz families of states of baryon number one; the families include the known baryon octet and decuplet families. The symmetry-breaking mechanism is studied and trajectory and mass formulas are derived in various approximations. (auth)

**21179** SELF-CONSISTENT REGGE SINGULARITIES. II. Halliday, I. G.; Saunders, L. M. (Imperial Coll. of Science and Tech., London). Nuovo Cim., 60A: 494-506(Apr. 1, 1969).

The unitarity equation for the $2 \to 3$ production amplitude involving simple particles is studied by using the multi-Regge model for the $2 \to N$ amplitude. An expression for Im T is derived which allows a simple discussion of the j-plane singularities of the amplitude. Insistence on consistency of input poles and residues with output yields a relation between the trajectory and Reggeon couplings. When the result is combined with that of the unitarity equation for the elastic $2 \to 2$ reaction a closed set of equations for the trajectory and couplings is obtained. (auth)

**21180** EFFECTS OF SCREENING ON THE COULOMB S-MATRIX. Calucci, G. (Istituto Nazionale di Fisica Nucleare, Trieste, Italy. Univ., Trieste, Italy). Nuovo Cim., Lett., 1: 470-2(Mar. 21, 1969).

A screen with an exponential tail is proposed. It is found that this screen could be more related to the physical situation than the finite-range potential studied previously. Comparison of the two results shows that the shape of the screen has some effect in the structure of the S-matrix. (J.F.P.)

## Particle Accelerators

*Refer also to abstracts 20948, 20975, 21034, 21063, and 21147.*

**21181** (CEAL-1046) LASER-INDUCED POLARIZED PHOTON BEAM AT THE CAMBRIDGE ELECTRON ACCELERATOR. Milburn, Richard H.; Sauer, Jon R.; Sinclair, Charles K. (Tufts Univ., Medford, Mass. Dept. of Physics); Fotino, Mircea (Cambridge Electron Accelerator, Mass.). Nov. 15, 1968. Contracts AT(30-1)-1984; AT(30-1)-2076. 39p. Dep. CFSTI.

The technical characteristics and status of the CEA program initiated in 1964 on the development of laser-induced photon beams are reported. It is shown that beams of such photons can be obtained routinely for use in certain high-energy experiments in which low intensities are compensated by a high degree of polarization and a harder energy spectrum. The present level of a few thousand photons per pulse is found to be more than satisfactory for bubble chamber applications. The applicability of the laser beam as a nondestructive probe for beam studies was also demonstrated by measuring the distribution of particle densities

in space and time. Attention is drawn to the applicability of this technique to similar beam studies in electron and possibly proton storage rings and particularly to the analysis of interacting beams in regions inaccessible by other methods. (L.B.S.)

**21182** (GA-9221) NEUTRON CAPTURE GAMMA RAY FACILITY USING AN ELECTRON LINEAR ACCELERATOR. Orphan, V. J.; Hoot, C. G.; Carlson, A. D.; John, Joseph; Beyster, J. R. (Gulf General Atomic, Inc., San Diego, Calif.). [1968]. Subcontract 3032. 38p. Dep. CFSTI.

For Oak Ridge National Lab., Tenn.

A versatile facility for the study of resonance neutron capture gamma-ray spectra with high energy resolution is described. An electron linear accelerator is used to provide a pulsed beam of neutrons. Gamma-ray spectra are measured using a Ge(Li)–NaI(Tl) spectrometer. The gamma-ray pulse height and the neutron time-of-flight information are stored using an on-line computer. The salient features of the capture facility are described and spectra resulting from the capture of neutrons in natural tungsten are displayed. (auth)

**21183** (IFVE-INZH-68-49-K) METHOD FOR DEFINING THE REGIME OF ACCELERATION IN THE INJECTOR OF THE ACCELERATOR OF THE IHEP. Afonin, A. G.; Il'evskii, S. I.; Kapchinskii, I. M.; Popinenkova, L. M.; Teplyakov, V. A. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). 1968. 21p. (In Russian). Dep.

A method for defining the RF field levels and phases of the cavities is described for the 100-MeV proton linac I-100 as the injector of the accelerator of the IHEP. The zero current technique, which allowed to find the threshold of the RF field levels and phases is described. The choice of the buncher's regime and the experimental data of some parameters of the Linac I-100 are discussed. (auth)

**21184** (NP-tr-1731) USE OF TRITIUM TARGETS IN A LOW-ENERGY ACCELERATOR AND THE FALL-OFF OF THEIR NEUTRON YIELD. Cordero, F. Translated by C. R. Brightmore for Atomic Energy Research Establishment, Harwell, Eng., from An. Fis., 64: No. 1-2, 25-32(1968). 10p. Dep.

Measurements of the rate of decrease in yield of neutrons from thick tritium-titanium targets have been made. The targets were used in a low-energy accelerator (150 keV) to obtain a pulsed neutron source. The geometry and the operating conditions of the targets are described in connection with the study of the factors affecting the practical service life. All targets were subjected to moderate deuteron current, from 30 to 200 μA, at an acceleration voltage of 150 kV (peak current 3 to 4 mA, pulse length 1–3 ms, duty ratio 2.5%). The yield dropped rapidly to one-half when the integrated current reached 0.7–1 C (2.5 to 3 hours half-life at 50 μA). The neutron flux drops to about 0.1 of original after 5 C. No noticeable drop in the target's neutron yield was observed after 50 C. The discussion relates mainly to the processes which determine the life of tritiated targets. (auth)

**21185** (RHEL/R-172) NIMROD OPERATION AND DEVELOPMENT. Quarterly Report, April 1–June 30, 1968. Gray, D. E. (ed.) (Rutherford High Energy Lab., Chilton (England)). Sept. 1968. 20p. Dep. UK 3s. 6d.

The Nimrod beam was on for high energy physics research for 86% of H.E.P. scheduled operating time. Twelve experiments were continued, and two were commenced in the period under review. Some experimental work on a resonant extraction system for Nimrod is discussed. Radiation survey measurements associated with both of Nimrod's extracted proton beams are given. Radiation dosimetry studies of the integrated absorbed dose of the Nimrod inner vacuum vessel indicate a decreased rate of dose accumulation when the extracted beam mode of operation is employed, as against the scattered-out beam mode. (auth)

**21186** (RHEL/R-173) A RESONANT EXTRACTION SYSTEM FOR NIMROD. Harold, M. R. (Rutherford High Energy Lab., Chilton (England)). Nov. 1968. 22p. Dep. UK 4s. 6d.

Using the computer program NIMDYN, beam behavior under resonant conditions was studied and the properties required of the extraction magnets determined. Particular attention was given to the method for causing particles of all betatron amplitudes to leave the stable region in such a way as to result in a small emittance at the beginning of the external transport system. It is shown that there is a choice of methods of spilling the beam, each resulting in different extracted beam characteristics, but all of which would lead to a much higher extraction efficiency than that of the Piccioni system in present use. (auth)

**21187** (RHEL/R-174) COMPUTER STUDY OF VERTICAL BEAM BLOW-UP DURING RESONANT EJECTION FROM NIMROD. Ranft, J.; Stevens, T. J. (Rutherford High Energy Lab., Chilton (England)). Dec. 1968. 18p. Dep. UK 3s.

Computer studies of beam behavior in the vertical phase plane are reported, and the coupling resonances present in Nimrod near the radial $\frac{2}{3}$ resonance are studied. These coupling resonances result in a vertical beam growth during resonant ejection, which is smaller than 10% for systems employing only continuous field perturbations, but which could be as large as 30% if lumped perturbation magnets were used to induce the wanted radial $\frac{2}{3}$ resonance. (auth)

**21188** (UCRL-18482) BEVATRON OPERATION AND DEVELOPMENT. 58, APRIL–JUNE 1968. Crebbin, Kenneth C.; Frias, Robert (California Univ., Berkeley. Lawrence Radiation Lab.). Jan. 17, 1969. Contract W-7405-eng-48. 16p. Dep. CFSTI.

The beam was on for 78.3% of the scheduled operating time and the Bevatron accelerated $1.9 \times 10^{18}$ protons. Three primary experiments completed data taking this quarter. The final target areas in the new dual-channel external proton beam facility were brought into operation. Operation of the new facility and the beam-switching modes are discussed. During a shutdown in May, measurements were made of the magnetic field of the Bevatron. Data were collected using a PDP-8 computer and associated hardware. The speed change of the main motor generators during pulsing was again reduced to minimize damage to the generator poles from cyclic loading. This reduced the flattop length from the original 1000 to 500 msec. A new mode of flattop pulsing is under study to reduce the large generator speed change during flattop and to allow us to run long flattops without cyclic damage to the generator poles. (auth)

**21189** (UCRL-Trans-1390) MOTION OF PARTICLES IN THE "ADGEZATOR". Ivanov, I. N.; Iovnovich, M. L.; Kuznetsov, A. B.; Obukhov, Yu. L.; Reshetnikova, K. A.; Rubin, N. B.; Sarantsev, V. P.; Yarkovoi, O. I. (Joint Inst. for Nuclear Research, Dubna (USSR)). Translated by T. Watt for Univ. of California, Lawrence Radiation Lab., Berkeley, from report JINR-P9-4132. 28p. Dep. CFSTI.

Main conditions which the bunch must satisfy and the method of producing them; quasistationary states of the electron ring, intrinsic fields and forces in the ring; equations and constants of motion; and two distribution functions are discussed. Also, analysis of the adiabatic behavior of a beam; accelerating field as a function of the adgezator parameters; wall screening effects; contribution of resonances; ion injection; and extraction of the electron ring from the adgezator are considered. (W.H.K.)

**21190** (UCRL-Trans-1392) STABILITY OF AN ELECTRON-ION RING. Bonch-Osmolovskii, A. G.; Ivanov, I. N.; Iovnovich, M. L.; Makhan'kov, V. G.; Perel'shtein, E. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of High Energy). Translated by T. Watt for Univ. of California, Lawrence Radiation Lab., Berkeley, from report JINR-P9-4138. 12p. Dep. CFSTI.

Basic questions connected with the stability of an electron-ion ring in an external magnetic field are discussed. Instabilities characteristic both for electron beams in magnetic fields (high-current accelerators) and electron–ion systems (plasmas) are studied. (W.H.K.)

**21191** LINEAR ELECTRON ACCELERATOR FOR INDUSTRIAL USE. Levin, V. M.; Rumyantsev, V. V.; Muntyan, V. I. At. Energ. (USSR), 26: 89-91(Jan. 1969). (In Russian).

During 1967 a linear waveguide electron accelerator was placed in operation at the D. V. Efremov Scientific Research Institute for Electrophysical Instruments, producing 4 to 12 MeV electrons. Under nominal operating conditions, the power level of the accelerated electron beam exceeds 5 kW. The maximum beam power, 5 to 7 kW, is obtained at an electron energy between 6 and 10 MeV, corresponding to a mean current of 800 to 500 μamp. The nominal pulse frequency is 500 per second while the duration of pulses is about 3 μsec. The accelerator operates with an efficiency of about 10%; its heat exchanger requires less than 10 $m^3$/hr of cooling water. During the acceleration process, the electrons are kept within the longitudinally constant magnetic field of the solenoid. Care was taken in the design to prevent the distortion of the magnetic field. Since it was started up, the accelerator has been in continuous use for irradiation tests and dosimetric studies. (TTT)

**21192** IMPROVEMENTS IN AND RELATING TO VACUUM CHAMBERS FOR CIRCULAR PARTICLE ACCELERATORS. (to Feldmuhle Aktiengesellschaft). British Patent 1,145,759. Mar. 19, 1969. Priority date Dec. 4, 1965, Germany.

A toroidal vacuum chamber which has a toroidal structural body member that is composed essentially of sintered alumina for use in a circular-path particle accelerator is described. (W.H.K.)

**21193** OMEGA PROJECT AT CERN. Michelini, Aldo (CERN, Geneva). Rend. Semin. Mat. Fis. Milano, 38: 137-68(1968). (In Italian).

The so-called "Omega Project" of CERN is described in some detail. The main parameters of the project are justified on the basis of the wanted resolutions and trigger rates. Some of the possible applications to high-energy experiments are briefly illustrated. (auth)

**21194** COUPLING WIDE BAND COAXIAL RESONATORS BY ACCELERATION OF PARTICLES. Susini, Alfredo (CERN, Geneva). Alta Freq., 37: 299-313(1968). (In Italian).

A method of calculus for determination of the functioning of coupled wide band coaxial resonators is presented. The geometrical relations allowing selection of the band desired are established. The conditions are established which minimize anodic losses of the power tube, the installed power, and the power in the radiofrequencies effectively operating. The technique may be applied to orbital accelerators like the Betatron. Calculations are developed for systems characterized by two impedance peaks and by three impedance peaks. Practical adaptation of the former case is reported. The theory does not yet calculate response to harmonics introduced in the tube. Appendixes detail mathematical derivations and solutions of new functions and analyze several electronic circuits in a transformer. (BBB)

**21195** PARTICLE TRAJECTORIES IN INCLINED FIELD ACCELERATION TUBES OF MINIMUM SECTION LENGTH. Gyarmati, Borbala; Koltay, Ede. ATOMKI (At. Kut. Intez.) Kozlem., 10: No. 3, 1-14(Dec. 1968). (In Hungarian).

Numerical calculations to study the properties of the ion and electron trajectories formed in inclined field tubes were carried out in a simple approximation. The effect of the length of inclined-field sections on the amplitude of trajectory oscillation was investigated and the minimum section length sufficient to retain the secondary electrons was looked for. Decreasing the section length results both in the simplification of the initial conditions and in a higher position stability of the accelerated beam. The programs used are suitable for any trajectory computation in the case of constant section length. (auth)

**21196** NEUTRAL ATOMS IN THE BEAM OF A HF ION SOURCE. Bodizs, Denes. ATOMKI (At. Kut. Intez.) Kozlem., 10: No. 3, 29-35(Dec. 1968). (In Hungarian).

The ratio of the neutral atom current to ion current ($I^0/I^+$) has been investigated in the beam of the HF ion source for the 1 MV nominal voltage pressurized Van de Graaff generator in ATOMKI as a function of the oscillator power and extraction voltage. The $I^0/I^+$ was found to be between 0.35 and 1.7. By focusing the ion beam and putting in a diaphragm the $I^0/I^+$ becomes 0.08 to 0.75. (auth)

**21197** MAINTENANCE OF ELECTRON BEAM STABILITY IN MEDICAL BETATRON. Hattori, Hiroyuki; Ueda, Toshio (Aichi Cancer Center, Japan). Nippon Igaku Hoshasen Gakkai Zasshi, 28: 1279-82(Dec. 1968). (In Japanese).

Radiotherapeutic treatment requires reproducible dose and its distribution of beam. To maintain beam stability in betatron electron treatment, it is necessary that the three factors of electron energy, deflection voltage making beam symmetry, and dose conversion factor are constant. These factors were measured for the Toshiba medical betatron, and it was found that the two factors excepting electron energy vary considerably. The monthly check is desirable for electron energy, and the daily corrections are needed for deflection voltage of higher energy and dose conversion factors so that the accuracy of dose and its distributions are maintained at less than ±3% error. The daily correction of beam symmetry is fairly laborious, so it is desirable that the automatic balancing device for correcting the beam asymmetry is mounted on the betatron. (auth) (NSA of Japan)

**21198** DEVICE FOR PRODUCING A D.C. HIGH VOLTAGE. Katagiri, Shinjiro (to Hitachi Ltd.). Japanese Patent 1968-26831. Nov. 7, 1968. Filed May 13, 1966.

By the method proposed, the high voltage source for a charged-particle accelerator is improved. It includes the following: a circuit for generating a dc high voltage, and a means for transmitting an ac power to the high-voltage side from the earth side via two condensers in parallel. (NSA of Japan)

**21199** METHOD AND DEVICE FOR MONITORING THE WAVE-SHAPE OF AN IRRADIATION ELECTRON CURRENT. Okabe, Shigeru (to Osaka Prefecture). Japanese Patent 1968-26679. Nov. 15, 1968. Filed Apr. 5, 1963.

By the method proposed, the wave-shape of an electron current, in a pulsed electron accelerator, can be monitored constantly, both accurately and easily. A thin metal foil is placed either near the irradiation window or in the evacuated electron path and emits secondary electrons. The wave-shape of the emitted electrons is amplified and monitored. By this means, the wave-shape and the magnitude of the pulsed irradiation electron current can be monitored without obstructing the electron irradiation. Another method uses an electrode to emit secondary electrons, which is placed either in the path or at its end, and an electrode to collect the emitted electrons. (NSA of Japan)

**21200** CIRCUIT FOR TRANSMITTING A SIGNAL VOLTAGE IN AN ELECTRON GUN. Imai, Takashi (to Kokusai Henatsuki K.K.). Japanese Patent 1968-27017. Nov. 20, 1968. Filed Mar. 9, 1964.

The design of a simple and compact circuit for transmitting a sharp pulse voltage to an electron-gun control electrode is described. (TSS) (NSA of Japan)

**21201** ACCELERATION OF MULTICHARGED HEAVY ICNS IN THE IPCR ORDINARY 160 cm CYCLOTRON. Miyazawa, Yoshitoshi; Tonuma, Tadao (Inst. of Physical and Chemical Research, Tokyo). Rikagaku Kenkyusho Hokoku, 44: 223-35 (Nov. 1968). (In Japanese).

The IPCR 160 cm ordinary type variable energy multiparticle cyclotron has an electromagnet and a radio frequency system of wide operation ranges and can accelerate various particles of different mass-to-charge ratios from protons to $Ne^{4+}$ ions. The weak focusing magnetic field ranges from 0.5 $Wb/m^2$ to 2.0 $Wb/m^2$ and the radio frequency varies from 5 to 12 MHz/sec. Multicharged heavy ions have been accelerated in the cyclotron since autumn 1966. At present, $C^{3+}$, $C^{4+}$, $N^{4+}$, $N^{5+}$ ions are accelerated with energies of 45 to 70 MeV, 45 to 120 MeV, 50 to 100 MeV, and 50 to 160 MeV, respectively, and a few microamperes of each kind of ions were extracted from the cyclotron. $C^{4+}$ and $N^{4+}$ ions are used for nuclear reaction experiments. The $O^{5+}$ ion could not be accelerated stably. The multicharged heavy ion source, of electron-bombarded hot cathode type was adopted, and nitrogen or $CO_2$ gases were fed in the source at a flow rate of 1 to 3 in *l*/min. The source life was mainly limited by erosion of the tungsten cathode bombarded with electrons and the source could be used successfully at arc powers of 2.0 to 2.5 kW. (auth) (NSA of Japan)

**21202** POSITRON YIELD FROM THICK TARGETS. Grishaev, I. A.; Efimov, V. P.; Kasilov, V. I.; Fisun, A. N. (Physical-Technical Inst., Kharkov). Ukr. Fiz. Zh., 13: 1926-9 (Nov. 1968). (In Russian).

Converter targets, made of materials with a large atomic number Z are used as positron sources on the basis of cascade reactions. The positron yields of such targets were measured, determining the correlation between the yield, the target thickness, and the energy of the positrons. The measurements were carried out under a zero angle with respect to the direction of the primary beam from the linear accelerator using Ta targets with thicknesses of 0.5, 1.0, and 2.0 radiation units for the 640-MeV beam, and 0.5, 1.0, 2.0 and 3.0 radiation units for the 1220-MeV beam. It was found that the maximum value of the conversion coefficient K for a positron energy of $E^+ < 0.2\ E_0^-$ has a maximum at thicknesses close to 2 radiation units; the maxima of the K curves lie in the $E^+ < 0.1\ E^-$ region. For the case of $E^+ > 0.2\ E_0^-$, the maximum lies at a target thickness close to 1 radiation unit. (TTT)

**21203** PARTICLE ACCELERATOR HAVING TUNABLE HIGH FREQUENCY POWER SUPPLY. Schnuriger, Jean Claude (to CSF-Compagnie Generale de Telegraphie Sans Fil). U. S. Patent 3,426,231. Feb. 4, 1969. Priority date Dec. 17, 1963, France.

A cyclotron is described wherein the resonant circuit formed by each of D electrodes and its support is tuned by rotating a panel extending radially in a box having a part thereof in the form of a cylindrical sector, said support extending into said box and having its extremity fixed to the back wall thereof. (Offic. Gaz.)

**21204** PRINCIPAL PROPERTIES AND COEFFICIENTS OF ABERRATION FOR SUPERCONDUCTING LENSES WITH HOLMIUM POLES. Bonjour, Pierre (Faculte des Sciences, Orsay, France). Compt. Rend., Ser. A, B, 268: 23-6(Jan. 6, 1969). (In French).

The focal distance, the position of the immersed center, and the coefficients of spherical aberration and chromatic aberration are calculated for lenses with holmium poles, as a function of the width of the pole gap and the electron energy, for several values of the maximum induction. (tr-auth)

**21205** PARTICLE ACCELERATION TUBE HAVING ELECTRIC FIELD CONTROL MEANS. Purser, Kenneth H. (to High Voltage Engineering Corp.). U. S. Patent 3,423,684. Filed Feb. 15, 1965.

The invention relates to the acceleration of charged particles

to high velocity, and in particular to acceleration tubes comprising a multiplicity of alternating insulating rings and apertured electrodes whose electric potential increases progressively so as to provide an electric field for the acceleration of charged particles within and along the length of the acceleration tube. When charged particles are injected into such an acceleration tube, rather than released from a source within it, it is necessary that the aperture of the apertured electrode through which the charged particles enter the acceleration tube be sufficiently large to accommodate the incoming charged particles. This large aperture, in turn, is accompanied by a relatively strong focussing action whose focal and magnification properties vary with the potential difference across the acceleration tube. The invention comprehends, in combination with such an acceleration tube, a grid-like structure covering the aperture of one of the apertured electrodes at the low-energy end of the acceleration tube, whereby the above-mentioned variable and relatively strong lens action is eliminated. In the following detailed description, the invention is described with particular reference to its application to tandem-type electrostatic accelerators of the type described in Nuclear Instruments and Methods, Volume 8 (1960) at pages 195-202. However, the invention is not limited to this particular application. (Offic. Gaz.)

**21206** TOSHIBA MEDICAL ELECTRON LINEAR ACCELERATOR, LMR-13. Kiuchi, Masaaki; Takata, Koji (Tokyo Shibaura Electric Co., Kawasaki, Japan). Toshiba Rebyu., 24: 183-90(Feb. 1969). (In Japanese).

The medical linac LMR-13 is now being successfully used at several universities and hospitals in Japan as a high-energy electron and x-ray therapy tool. It has such main features as: 13-MeV electron beams, new systems of controlling and monitoring electron beam radiation, variable energy beams for electron therapy, easy control of the X-ray dose rate, and 420° rotation therapy. Its ratings are: x-ray output: 8/10MV, 500R/min at 1m, and electron beam output: 8/10/12/13 MeV, 200 to 1,000 R/min at 1m. (auth) (NSA of Japan)

**21207** DYNAMICS OF TRANSVERSE INSTABILITY OF BEAM IN LINEAR ELECTRON ACCELERATOR. Voskresenskii, G. V.; Serebryakov, Yu. N. At. Energ. (USSR), 25: 507-13(1968). (In Russian).

The problem of electron beam transverse instability in a linear accelerator, due to excitation of nonsymmetrical electromagnetic fields (model $HE_{11}$) is resolved. The integral-differential equation for the amplitude of excited field is derived. This equation describes the transient behavior of the beam instability when the particle acceleration and focusing are taken into account and when the nonvanishing value of the energy velocity in the slow-wave structure is also considered. It is proven that the positive feedback, due to the excited field drift in a direction opposite to that of the electron bunch movement, results in exponential increase of the instability in a system. A simple criterion of stability is established for calculating the threshold values of the accelerators current. The influence of an homogeneous focusing magnetic field and of resistive losses on the instability build-up are investigated. The effect of section-partitioning on the process instability is defined. Also, quantitative appraisals are given. (auth)

**21208** SOURCE OF POLARIZED NEGATIVE HYDROGEN AND DEUTERIUM IONS. Lawrence, G. P.; Ohlsen, G. G.; McKibben, J. L. (Los Alamos Scientific Lab., N. Mex.). Phys. Lett., 28B: 594-6(Mar. 3, 1969).

A high-performance source of polarized negative hydrogen and deuterium ions is described. The source uses charge exchange in cesium to produce an intense metastable beam, "spin filtering" of the metastable atoms to select a particular nuclear substate, and charge exchange in argon to selectively convert the polarized metastable atoms to negative ions. A $D^-$ current of 600 nA with $P_3 = 0.78$ and an $H^-$ current of 300 nA with $P = 0.90$ have been obtained. (auth)

**21209** EFFICIENCY OF AN ELECTROSTATICALLY FOCUSED ELECTRON IMPACT ION SOURCE. Ozard, J. M.; Russell, R. D. (Univ. of British Columbia, Vancouver). Appl. Sci. Res. (The Hague), 20: 55-60(Jan. 1969).

Naidu investigated the inverse problem of particle motion which specifies the electrostatic field to guide charged particles along a prescribed set of paraxial paths. As an example, an application to mass spectrometry was cited. From the theory an electric field was specified that should focus charged particles so that a gas source of greater efficiency than a modified Nier source appeared possible. An ion source is constructed employing the proposed focusing field. Experimentally the new source is found to have an overall efficiency of $4 \times 10^{-4}$, the same as the modified Nier source. The new ion source produces ions of 0.1 eV energy spread and a half angle of divergence of 0.5 deg. An explanation for the observed efficiency is given, and the reasons for the failure to improve the performance as predicted by Naidu are discussed. (auth)

**21210** OPTICS OF DIPOLE MAGNETS. Livingood, John J. New York, Academic Press, Inc., 1969. 274p.

Topics discussed include radial motion in one magnet, axial motion in one magnet, dispersive one-magnet systems, dispersive multimagnet systems, radial matrix coefficients for three magnets, radial beam envelopes, axial beam envelopes, and routine for envelopes in one or two magnets. Also, achromatic systems, doubly achromatic systems, beam bending by two magnets with achromatic image, beam bending by one magnet and two quadrupoles with achromatic image, achromatic single magnets, beam translation by two magnets with achromatic image, dispersed or achromatic image with two magnets, chromatic aberrations, correction of certain aberrations, and principal planes are considered. An extensive bibliography is included. (W.H.K.)

**21211** PRECISION BEAM ENERGY MEASUREMENTS AND THEIR RELATION TO THE PROTON MAGNETIC MOMENT. Marion, Jerry B. (Univ. of Maryland, College Park). pp 410-26 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

A method for the precision measurement of beam energies using an RF-cavity velocity gauge is described. The relation of beam energy to the proton magnetic moment is discussed. A measurement of $\mu_p/\mu_n$ made using this relation is reported. (J.W.R.)

**21212** A FAST, WIRE-PLANE PROFILE MONITOR FOR EXTRACTED PROTON BEAMS. Simanton, J. R.; Marquardt, R. F.; Hornstra, F. Jr. (Argonne National Lab., Ill.). Nucl. Instrum. Methods, 68: 209-12(Feb. 15, 1969).

Wire planes, operating in air as ionization collectors, have been instrumented to provide continuous and essentially instantaneous readout of extracted proton beam profiles at the Zero Gradient Synchrotron. The value of the profile monitor as a diagnostic tool and as input for computer optimization of beam on external targets is illustrated and discussed. (auth)

**21213** ENERGY RESOLUTION AND DISTRIBUTION MEASUREMENTS ON THE KARLSRUHE CYCLOTRON. Chaudhri, M. Anwar (Research Inst. and Nuclear Energy Div., Frankfurt am Main). Nucl. Instrum. Methods, 68: 329-32(Feb. 15, 1969).

The energy spread and energy distribution in the full external beam of the Karlsruhe cyclotron have been observed as a function of the dee-voltage and the dee-frequency. It has been shown that from a systematic study it is possible to find a set of machine parameters at which a good beam quality with energy resolution (fwhm) of better than 0.2% can be obtained. (auth)

**21214** A SCATTERING CHAMBER FOR THE EXTERNAL BEAM OF THE KARLSRUHE ISOCHRONOUS CYCLOTRON. Kohout, G.; Buschmann, J.; Christaller, G.; Gindler, J. E.; Hartmann, D.; Michel, F.; Muenzel, H.; Schwarzbach, E. (Nuclear Research Center, Karlsruhe, Ger. Argonne National Lab., Ill.). Nucl. Instrum. Methods, 68: 325-8(Feb. 15, 1969).

A scattering chamber was constructed for a maximum of flexibility in application. Two turntables allow a wide arrangement of detectors and attachments. A vertical target changer permits successive introduction of ten targets without breaking the chamber's vacuum. (auth)

**21215** GAS TARGET CELL FOR A PRECISION SCATTERING CHAMBER. Wallace, W. J.; Bisson, A. E.; Davis, R. H. (Florida State Univ., Tallahassee). Nucl. Instrum. Methods, 68: 337-40(Feb. 15, 1969).

A gas target cell with demountable cylindrical windows has been developed for use with the Florida State University 45.7 cm (18") scattering chamber. Designed for maximum experimental flexibility, this cell allows observation throughout an angular range from 20° to 170°. Several interchangeable gas handling plugs, one of which incorporates a Ti getter pump within the cell interior, are described. A 16 detector array permits the simultaneous acquisition of 16 excitation functions or the efficient measurement of detailed angular distributions by angular displacement of the detector ring. This cell has been used at a gas pressure of 35 Torr for measurements of cross sections for elastic scattering of alpha particles by $^{20}Ne$ and $^{36}Ar$ in the energy range from 10 to 14 MeV. (auth)

**21216** SIMPLE METHOD FOR DETERMINING WAIST-TO-WAIST TRANSFER PROPERTIES OF QUADRUPOLE DOUBLETS AND TRIPLETS. Resmini, F. (Univ. of California, Berkeley). Nucl. Instrum. Methods, 68: 235-9(Feb. 15, 1969).

A new method is reported which allows the exact determination of the waist-to-waist transfer properties of quadrupole doublets and triplets. For any given geometry and finite emittance beam the entire set of available solutions can be found and the quadrupole strengths evaluated. Two examples are given for an asymmetric triplet, for the purpose of illustrating the application of the method. (auth)

**21217** TESTING OF A DEUTERATED POLYPHENYL TARGET IN A BEAM OF DEUTERONS. Cuypers, M.; Peters, J. M.; Weber, G. (Univ., Liege). Nucl. Instrum. Methods, 68: 245-50(Feb. 15, 1969). (In French).

A deuterated target of novel design has been developed. It is composed of a high polymer, the polyphenyl, in which deuterium forms an integral part of the molecule. As a first step before testing the target of tritiated polyphenyl, the behavior of deuterated polyphenyl targets in a beam of deuterons for the production of 3 MeV neutrons according to the $D(d,n)^3He$ reaction was examined. (auth)

**21218** LES ACCELERATEURS DE PARTICULES. (Particle Accelerators). Boussard, Daniel. Que Sais-Je? Le Point des Connaissances Actuelles, No. 1316. Paris, Presses Universitaires de France, 1968. 136p.

The discussion of particle accelerators covers targets and projectiles, and electrostatic, linear, and circular accelerators. Also considered are various types of new accelerators and storage rings. (J.F.P.)

# PHYSICS (NUCLEAR)

## Neutron Interactions with Matter

*Refer also to abstracts 20974, 20977, 21182, and 21344.*

**21219** NEUTRON THERMALIZATION MEASUREMENTS IN GRAPHITE. Hanna, Nabil N.; Harris, M. J. (Univ. of Manchester, Eng.). J. Nucl. Energy, 23: 29-37(Mar. 1969).

Using a pulsed source of 14-MeV neutrons, the rate of attainment of the asymptotic neutron spectrum was measured internally for 16 graphite blocks, and externally for 7 blocks, in the $B^2$ range 2.99 to 25.30 $\times 10^{-3}$ $cm^{-2}$ using a silver transmission technique. Values of 36.2 ± 4.9 $\times 10^5$ $cm^4$ $sec^{-1}$ and 660 ± 115 μsec were obtained for the diffusion cooling coefficient and the infinite medium thermalization time constant, at a graphite density of 1.685 $gcm^{-3}$. The former result agrees with that obtained from decay constant measurements, while the latter agrees with some recent similar work but not with earlier measurements. Reasons for this are suggested. The time required to attain an equilibrium spectrum in graphite was found to be about 2.1 msec., independent of $B^2$, a result in good agreement with that of other authors. The $B^2$ range investigated went to values higher than any reported previously for graphite and exceeded the theoretical ($B^2$). The results suggested that an apparent asymptotic spectrum was attained over the whole range, although for $B^2 > 17.3 \times 10^{-3}$ $cm^{-2}$ counting statistics were insufficient to establish this with certainty. (auth) (UK)

**21220** INTERPRETATION OF THE NEUTRON WAVE EXPERIMENT. Wood, J. (Queen Mary Coll., London). J. Nucl. Energy, 23: 17-28(Mar. 1969).

The behavior, in a moderator, of the neutron density wave propagating from a modulated thermal neutron source is studied. The Boltzmann equation, in the diffusion approximation, is solved numerically to obtain a complete set of complex eigenfunctions whose amplitudes are obtained from the oscillating source condition. By introducing an effective (complex) wave parameter the detector response as a function of time, and position is examined. The feasibility of measuring asymptotic values of the wave parameters, particularly when critical values of frequency and buckling have been exceeded, is investigated, and the effect of various source energy distributions demonstrated. The calculated values of the fundamental wave parameters $\alpha_0$, $\xi_0$ are compared directly with the measured values of Perez and Booth, for a graphite system with $B_t^2 = 0.00596$ $cm^{-2}$. (auth) (UK)

**21221** DIFFUSION AND ABSORPTION PARAMETERS OF HEAVY WATER. Silk, M. G.; Wade, B. O. (Atomic Energy Research Establishment, Harwell, Eng.). J. Nucl. Energy, 23: 1-16(Mar. 1969).

A pulsed-neutron experiment was carried out on large systems of reactor grade heavy water. From the infinite medium decay constant the thermal neutron absorption cross section of pure $D_2O$ was estimated to be 1.274 ± 0.10 mb, and that for deuterium 0.485 ± 0.065 mb. The diffusion coefficient of pure $D_2O$ was found to be 0.824 ± 0.0025 cm, in reasonable agreement with other measurements. The experiment was confined to large systems, so that it was not possible to estimate accurately the diffusion cooling coefficient; the value obtained was 12.9 ± 2.7 $\times 10^5$ $cm^4$ $sec^{-1}$, significantly greater than most previous values. An examination of all the experimental evidence suggested that the discrepancy may be due to the shape of the moderator. (auth) (UK)

**21222** ONE-SPEED NEUTRON WAVE PROPAGATION WITH A SOURCE OFF THE INTERFACE. Baldonado, O. C.; Erdmann, R. C. (Univ. of California, Los Angeles). Jap. J. Appl. Phys., 8: 374-82(Mar. 1969).

One-speed diffusion and transport theory was used to solve the problem of neutron wave propagation in a two-region system. The source was at a finite distance to the left of the interface of the adjacent half-space. The solution in both models corresponds to the interpretation of the classical wave problem. The waves propagate until they reach the interface. At the interface, there is a component which is reflected, whereas another component is transmitted. Two coupled singular integral equations were solved simultaneously to evaluate the coefficients. One of the equations is of the Riemann–Hilbert type with discontinuous coefficients. There exists a discrete separation constant for the diffusion model for all oscillation frequencies. For the transport model, it is seen that there is a limiting frequency above which the discrete waves apparently disappear. Thus, a mixture of discrete and continuum waves, incident to an interface from the left medium may give rise to purely continuum or to a mixture of discrete and continuum waves on the right. Also, it is seen that a purely continuum incident wave may give rise to both discrete and/or continuum transmitted components. (auth)

**21223** MULTIPLE SCATTERING IN DOUBLE DIFFERENTIAL MEASUREMENTS AS A FUNCTION OF NEUTRON PATH LENGTH. Slaggie, E. L. (Gulf General Atomic Inc., San Diego, Calif.). Nucl. Sci. Eng., 36: 105-7(Apr. 1969).

Calculations were performed for neutron scattering by a slab with a limitation on path length in order to simulate scattering in a slab with spacers. The results suggest the need for multiple scattering corrections in double differential measurements in such systems. (J.W.R.)

**21224** ITERATION AND INTERMEDIATE RESONANCE. NEUTRON ABSORPTION IN MULTINUCLIDE SYSTEMS. de Kruijf, F. (Reactor Instituut, Delft, Netherlands). Nucl. Sci. Eng., 36: 107-9(Apr. 1969).

An iterative procedure for obtaining the intermediate resonance parameter for a homogeneous mixture of nuclides is outlined. (D.C.W.)

**21225** ELEMENTARY SOLUTIONS OF THE REDUCED THREE-DIMENSIONAL TRANSPORT EQUATION. Kaper, Hans G. (Stanford Univ., Calif.). J. Math. Phys. (N. Y.), 10: 286-97(Feb. 1969).

By treating one of the space dimensions exactly and approximating the other two by the exp $(-iB \cdot r)$ assumption, which is suggested by asymptotic transport theory, it is possible to reduce the three-dimensional transport equation to an equation that is of one-dimensional form and that still contains details of the complete three-dimensional angular distribution. The method of elementary solutions for the reduced transport equation was developed for the case of time-independent monoenergetic neutron transport in homogeneous media with isotropic scattering. The spectrum of the transport operator consists of a pair of discrete points if $B^2$ is sufficiently small and a continuum which occupies a two-dimensional region in the complex spectral plane. The eigenfunctions possess full-range and half-range orthogonality and completeness properties, which are proved via the solution of two-dimensional integral equations using the theory of boundary-value problems for generalized analytic functions. As applications, the Green's function for an infinite homogeneous prism and the albedo operator for a semi-infinite homogeneous prism were solved. Also discussed are possible generalizations of the method to more complicated forms of the reduced transport equation. (auth)

**21226** THEORY OF THE PROPAGATION OF THE PLANE-WAVE DISTURBANCES IN A DISTRIBUTION OF THERMAL NEUTRONS. Duderstadt, James J. (California Inst. of Tech., Pasadena). J. Math. Phys. (N. Y.), 10: 266-76(Feb. 1969).

The propagation of plane-wave disturbances in a neutron gas in thermal equilibrium with a moderator was studied using the linearized Boltzmann equation. The eigenvalue spectrum of the appropriate Boltzmann transport operator was investigated for both polycrystalline and noncrystalline media, and several necessary conditions for the existence of a point spectrum (and hence for the existence of plane-wave propagation) are discussed. Techniques are presented which allow the solution of various boundary-value problems using this spectral representation. (auth)

**21227** NEUTRON DIFFUSION LENGTHS OF GRAPHITE-ABSORBER MIXTURES BETWEEN 200 AND 2000°K. Clendenin, W. W. (Los Alamos Scientific Lab., N. Mex.). Nucl. Sci. Eng., 36: 1-14(Apr. 1969).

The neutron diffusion length of graphite with an added 1/v absorber was calculated for temperatures from 200 to 2000°K. At each temperature, the entire range of absorption for which a diffusion length exists was examined. The largest such range, which occurs for 2000°K, extends from the absorption of pure graphite to a value corresponding to 7.3 b at 0.0253 eV. For all values of temperature and absorption, the diffusion length, L, in centimeters is given within 1% by $L = 0.8504\ T^{\frac{1}{4}}\ (\sigma')^{-\frac{1}{2}}\ [1 + \alpha(T)\ \sigma' - \beta(T)\ \sigma'^2]$, where T is the absolute temperature and $\sigma'$ (b) is the absorption cross section at 0.0253 eV. The temperature-dependent functions $\alpha(T)$ and $\beta(T)$ are given. Very good agreement exists between the values implied by this formula and recent measurements. Each calculated value of L was obtained as an eigenvalue of a $P_{11}$ approximation to the transport equation. The neutron energy spectrum is obtained accurately as the eigenfunction in the calculation. This spectrum shows the characteristic discontinuity

at the Bragg limit, previously known for beryllium, which varies in magnitude with the absorption. There is also a marked hardening of the spectrum with increasing absorption, which significantly affects the value of the diffusion length. (auth)

**21228** RESONANCE MODERATION OF NEUTRONS IN WEAKLY ABSORBING MIXTURES. Segev, M. (Argonne National Lab., Ill.). Nucl. Sci. Eng., 36: 59-66(Apr. 1969).

An approximate analytic solution to the infinite-medium slowing down equation is obtained for a weakly absorbing mixture of isotopes. It derives from a moment expansion of the integral equation and, by truncation, involves the average lethargy gain and the average square of the lethargy gain per collision in the mixture. It applies to the vicinity of a resonance if the isotope masses are not much different from each other or if the scattering power ($\xi \Sigma_s$) of the resonant isotope at the resonance peak is much higher than the scattering power of the background. It offers a simple description of the strong fluctuations in the collision density caused by wide or strong resonances of light and structural elements in fast mixtures. An important application of the theory is the evaluation of group cross sections. The theoretical estimate of the group removal cross section was compared with numerically-exact values and a discrepancy of a few percent was found. (auth)

**21229** NEUTRON DIFFUSION MEASUREMENTS IN WATER FROM 18 TO 280°C. Bowen, R. A.; Scott, M. C. (Univ. of Birmingham, Eng.). J. Phys., D (London), 2: 401-12(Mar. 1969).

The pulsed-neutron method was used to measure the temperature dependence of both the diffusion constant and the extrapolated end point in water. The measured temperature dependence of the diffusion constant was found to be in good agreement with the theoretical values predicted by the Nelkin kernel. Measurements of the extrapolated end point in a cylinder of diameter 7 in. and height 7 in. gave a value of 0.323 ± 0.013 cm, with a similar result for a 7 in. cubical system. For an 8 in. diameter cylinder 4 in. high, however, the value was 0.465 ± 0.039 cm, a change which would not be expected theoretically. The extrapolated end point was also measured at temperatures up to 250°C. For a 4 in. high cylinder no definite temperature dependence was observed, but in a 16 in. high cylinder there was an increase with temperature from 0.340 ± 0.030 cm at 18°C to 0.469 ± 0.021 cm at 250°C. (auth) (UK)

**21230** INELASTIC NEUTRON SCATTERING BY $^{36}$Ar CLOSE TO CONDENSATION. Andriesse, C. D.; Compagner, A.; Hasman, A.; Van Loef, J. J.; Van Zevenbergen, F. (Reactor Instituut Delft, Netherlands). Phys. Lett., 28A: 642-3(Feb. 10, 1969).

The dynamics of gaseous $^{36}$Ar near the coexistence region was studied by means of cold neutron scattering. The scattering cross section of $^{36}$Ar was determined to be 74 ± 2 barns. (auth)

**21231** NUTRON FLUX PERTURBATIONS IN FOILS. Turi, L. (Queen Mary Coll., London). J. Nucl. Energy, 23: 49-50(Mar. 1969).

Correction is made for erroneous results given for the activity of a 1/v-foil in a previous paper by Williams [NSA, 20: 29539] in which a general formula was developed for the activity of non-scattering neutron absorbing foil. Specific values are tabulated for the activity of the foil as a function of foil thickness per unit unperturbed flux. (UK)

**21232** IMPRASTIEREA NEUTRONILOR TERMICI. (Scattering of Thermal Neutrons). Bally, D. Bucuresti, Editura Academiei Republicii Socialiste Romania, 1966. 292p.

An extensive review of the application of thermal neutron scattering to studies of atomic and molecular structure and dynamics is presented. The interactions of neutrons with gases, liquids, and solids are discussed in detail. 342 references. (D.C.W.)

**21233** NEUTRON YIELDS AND THERMAL NEUTRON FLUXES IN SYSTEM LEAD–WATER, BOMBARDED BY HIGH ENERGY PROTONS. Vasil'kov, R. G.; Gol'danskii, V. I.; Grishkevich, Ya. V.; Lupandin, O. S.; Pimenov, B. A. At. Energ. (USSR), 25: 479-83(1968). (In Russian).

Absolute values of neutron yields and distributions of thermal neutron fluxes being generated in a lead–water system by high energy protons were measured. The experiments were carried out at the proton energies of 400, 500 and 660 MeV and with a lead target of various dimensions, a primary proton beam diameter being 4 to 4.5 cm. The maximum thermal neutron flux 7.3 · $10^{-3}$ neutron/sec · cm$^2$ · proton (±12%) was obtained, when the target diameter was about 14 cm. (auth)

**21234** NOTE ON THE TWO-GROUP TRANSPORT THEORY. Thielheim, K. O.; Bloecker, W. (Univ., Kiel). Z. Phys., 221: 9-16(1969).

In the case of one-way coupling, two-group transport theory specializes in a nontrivial way through the fact that additional discrete eigenfunctions occur within the range of continuous eigenfunctions. This problem is discussed in the present paper. Additional eigenvalues and eigenfunctions are presented. The full-range completeness theorem as well as the orthogonality and normalization relations are given. Expansion coefficients of the infinite-medium Green's function are presented as an example. (auth)

**21235** MEASUREMENTS OF NEUTRON SLOWING DOWN TIME IN GRAPHITE BY CAPTURE GAMMA-RAY DETECTION. Maekawa, Hiroshi; Yamamuro, Nobuhiro (Tokyo Inst. of Tech.). J. Nucl. Sci. Technol. (Tokyo), 6: 113-19(Mar. 1969).

The neutron slowing down time in graphite was measured by means of capture $\gamma$-ray detection. Bursts of fast neutrons produced by D-T reaction were injected into a graphite pile. Detection was by NaI(Tl) scintillator covered by metallic foil of either In, Cd, or Gd, serving as resonance absorber. The slowing down time was determined from the maximum point of the reaction rate registered by this counter and presented in the form of time spectrum. The values thus determined were 19.2 ± 0.6, 39 ± 3, 43.0 ± 0.7, 46.1 ± 1.0, 47.5 ± 0.8, 55 ± 2, and 85 ± 6 $\mu$s, for 1.58, 0.48, 0.44, 0.36, 0.30, and 0.17 eV, respectively. These values agree well with calculations based on crystal model. The time response of the resonance detector also was in reasonable agreement with calculation. The effects of the medium being finite and that of detector position on the observed slowing down time were estimated. From this experiment, it became clear that the process of the neutron slowing down shows some definite influence of the crystal effect of graphite and is explained pretty well by Williams' model. (auth)

**21236** INTERACTIVE GRAPHICS IN DATA PROCESSING: NEUTRON CROSS-SECTION EVALUATION. Creasy, R. J. IBM (Int. Bus. Mach.) Syst. J., 7: 355-64(1968).

An experimental computer program called SCORE, was developed which allows an evaluator to correlate data and calculate neutron cross sections interactively through a display console. A brief description is given of the computing environment (the computing system and its relation to the SCORE program), and system operation is discussed and exemplified by showing the steps necessary to perform data evaluation and curve generation. Capabilities that could usefully be added to SCORE are suggested. A prototype program to assist in the evaluation of this data was designed and implemented for the IBM System/360. As experience with the system increased, the design was modified (new functions were added and old ones were changed) and the version of the system described here evolved. Using a main storage partition under the System/360 Operating System (OS/360) with basic graphics support, SCORE uses the 2250 Model 1 display console with a 4K-byte buffer, character generator, alphanumeric keyboard, and light pen. The program is written in FORTRAN IV as implemented in the FORTRAN H-size compiler. This experimental prototype program has proved the feasibility of computer-aided neutron cross-section evaluation. Additional curve generation and statistical functions, such as the ability to do a least squares fit on data, should be added to make SCORE practical for operational use. An improved system structure is necessary to facilitate future system additions and to make the linkage editor overlay representation more compact. For better modeling and evaluation of data, the evaluator should be able to display parametric information abstracted from published experiment descriptions. (BBB)

## Nuclear Properties and Reactions, A≤ 5

*Refer also to abstract 20057.*

**21237** (ZFK–130) PROCEEDINGS OF THE SECOND CONFERENCE ON NUCLEAR REACTIONS WITH LIGHT NUCLEI AND NUCLEAR STRUCTURE, 16–21 OCTOBER 1967 IN ROSSENDORF. Mueller, Kh.; Schintlmeister, J. (eds.) (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)). Dec. 1967. 256p. (In Several Languages). (CONF-671070).

Separate abstracts were written for each of the 49 papers included. (J.W.R.)

*For abstracts of individual papers see: 21133, 21238–21241, 21257–21278, 21292–21302, 21333–21335, and 21374–21381.*

**21238** (ZFK–130, pp 190-3) THE STRUCTURE OF THE GIANT DIPOLE RESONANCE OF $^9$Be NUCLEUS. Majling, L. (Ceskoslovenska Akademie Ved, Rez. Ustav Jaderneho Vyzkumu); Smirnov, Yu. F.; Kukulin, V. I. (Moscow State Univ. (USSR). Inst. for Nuclear Physics).

The photodisintegration of $^9$Be was investigated in the many-particle shell model. A harmonic oscillator potential with Serber

forces and residual interactions was used. The calculated spectra of photonucleons were compared with experimental data and good agreement was found. (J.W.R.)

**21239** (ZFK-130, pp 209-10) A STUDY OF THE THREE PARTICLE REACTION H(d,2p)n AT 14 MeV. Kuehn, B.; Kumpf, H.; Moeller, K.; Moesner, J. (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)).

The two-dimensional spectra produced in the reaction p + d = p + p + n were measured at 14 MeV. The corresponding matrix elements were calculated using the pole graph approximation and the agreement with experiment was good. (J.W.R.)

**21240** (ZFK-130, pp 211-12) NEUTRON INDUCED REACTIONS ON $^3$He AT $E_n$ = 14.4 MeV. Antolkovic, B.; Paic, G.; Tomas, P.; Rendic, D. (Institut Rudjer Boskovic, Zagreb (Yugoslavia)).

A counter telescope in conjunction with a two-dimensional channel analyzer was used to measure the angular distribution for neutron elastic scattering and (n,d) and (n,p) reactions on $^3$He at 14.4 MeV. The data were compared with theoretical analyses. (J.W.R.)

**21241** (ZFK-130, pp 213-19) ROLE OF THE PHOTONUCLEAR POLARIZATION EXPERIMENTS IN THE INVESTIGATION OF THE THREE-BODY NUCLEAR STRUCTURE. Fetisov, V. N. (Akademiya Nauk SSSR, Moscow. Institut Fiziki).

It is shown that the measurement of polarization effects in photonuclear reactions on T and $^3$He yield valid information on the energy dependence of the magnetic amplitude for the photon energy interval. This in turn yields information on the sign of the S' state admixture and meson currents. Polarization effects were calculated for T($\gamma$,n)d and $^3$He($\gamma$,p)d at threshold to 15 MeV in the density matrix formalism. (J.W.R.)

**21242** INCONSISTENCY IN THE ANALYSIS OF ALPHA-PARTICLE SCATTERING. Abdelkader, Mostafa A. Int. J. Electron., 25: 177-80(Aug. 1968).

It is contended that the prevalent comparison of the measured differential cross sections for elastic scattering of alpha particles with the cross sections for 'pure Coulomb' scattering are meaningless for the high energies used in recent experiments. Attention is drawn to a classical scattering formula derived by A. O'Rahilly (1938), superseding that of Rutherford and based on a generalization of Coulomb's law for moving charges; it is held that such a formula, and not Rutherford's, is the correct one to use for comparison with experimental results. (auth) (UK)

**21243** NEW MODEL FOR TRINUCLEONS. Jain, S. C. (Allahabad Univ., India); Srivastava, B. K. J. Phys. A (London), 2: 214-9(Mar. 1969).

The binding energy, the bare form factor, and the photodisintegration, bremsstrahlung-weighted and integrated cross sections of the trinucleons ($^3$H and $^3$He) were calculated earlier by using a modified Feshbach wave function and a velocity-dependent potential. These properties of trinucleons with a modified Irving wave function are recalculated, using the same velocity-dependent potential. Better agreement is then found with experiments. This shows that the new model for the trinucleons is much more satisfactory than the earlier model using a modified Feshbach wave function. (auth) (UK)

**21244** AN IMPROVED S-STATE WAVE FUNCTION FOR $^2$H. Salem, S. M. (Alexandria Univ., Egypt). Nuovo Cim., 60B: 61-70(Mar. 11, 1969).

The lowest harmonic-oscillator shell-model wave function of $^3$H, $\Psi_0$, is modified by applying to it the potential-energy operator, $V_{ij}^C = \sum_{i<j}^3 J_{ij}(a_\tau(\tau_i \cdot \tau_j) + a_{\sigma\tau}(\sigma_i \cdot \sigma_j)(\tau_i \cdot \tau_j))$ (where $J_{ij} = \exp[-r_{ij}^2/r_C^2]$), together with the kinetic-energy operator, $T = -(\hbar^2/2m)\sum_{i=1}^3 \Delta_i$ (where $\Delta_i = \partial^2/\partial\rho_{ix}^2 + \partial^2/\partial\rho_{iy}^2) + \partial^2/\partial\rho_{iz}^2$). It has been shown that $\langle\Psi|T + V_{ij}^C|\Psi\rangle/\langle\Psi|\Psi\rangle$ (where $\Psi = A\Psi_0 + B(T + V_{ij}^C)|\Psi_0$ and $(T + V_{ij}^C)|\Psi_0 = C_1\Psi_1 + C_2\Psi_2 + C_3\Psi_3$) gives a better approximation to the lowest eigenvalue than $\langle\Psi_0|T + V_{ij}^C|\Psi_0\rangle/\langle\Psi_0|\Psi_0\rangle$. A typical short-range two-body central interaction given by Hu and Massey, which is charge symmetric and has Gaussian radial dependence, has been used in the Hamiltonian to investigate the improvement in the wave function. Considerable improvement has been found by this method. (auth)

**21245** THE $^2$H + d REACTION AT LOW ENERGIES. Fick, D. (Univ., Erlangen, Ger.). Z. Phys., 221: 451-63(1969). (In German).

It is shown that in the angular distributions of the $^2$H(d,p)$^3$H (using polarized and unpolarized deuterons) and likewise in the neutron polarization of the mirror reaction $^2$H(d,n)$^3$He the resonance found at $E_d \approx 105$ keV can be understood as a threshold resonance. From the experimental data $J^\pi = 2^{(+)}$, T = 0 is derived for spin, parity and isospin of the resonance. Additionally it is found that the resonant part of the reaction has a small coupling matrix element, linking the $^2$H + d channel with the $^2$H + p and $^3$He + n channels. (auth)

**21246** DIFFERENTIAL ELASTIC SCATTERING CROSS SECTIONS OF 14.4-MeV NEUTRONS BY HYDROGEN ISOTOPES. Basar, I.; Cerineo, M.; Tomas, P.; Miljanic, D. (Ruder Boskovic Inst., Zagreb). Fizika (Zagreb), 1: 105-18(1968).

The differential cross sections for n-p, n-d, and n-t elastic scattering were measured at the neutron energy of 14.4 MeV with a relative error of 2%. The absolute error obtained was 12% for n-p and n-d data and 20% for n-t data. The value for the anisotropy in n-p scattering was determined as 1.10 ± 0.03. (auth)

**21247** PROCEEDINGS OF THE THIRD INTERNATIONAL CONFERENCE ON ATOMIC MASSES, UNIVERSITY OF MANITOBA, WINNIPEG, CANADA, AUGUST 28-SEPTEMBER 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967. 914p. (CONF-670818).

Separate abstracts were prepared for the 43 papers included. (J.W.R.)

*For abstracts of individual papers see: 19998, 19999, 20067–20072, 20721, 20722, 21013, 21033, 21041–21043, 21211, 21248–21253, 21283, 21284, 21328, 21329, 21365–21372.*

**21248** BETA DECAY ENERGY SYSTEMATICS. Gove, N. B. (Oak Ridge National Lab., Tenn.). pp 119-34 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

Recent beta decay systematics, plotted by a computer, are discussed. (J.W.R.)

**21249** ACCURATE Q-VALUES FOR THE LIGHT MASSES. Browne, C. P.; O'Donnell, F. H. (Univ. of Notre Dame, Ind.). pp 508-26 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

$\beta$-values for various nuclear reactions on light nuclei were measured in order to determine if mass uncertainties could be reduced to those of the mass tables. (J.W.R.)

**21250** PERIODIC REGULARITIES IN THE BINDING ENERGY OF THE LEAST MASS ISOBARS. Selinov, I. P. pp 845-63 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

The periodic properties of nucleon shell filling, in analogy to atomic electron shell filling, are pointed out. Other periodic features, such as packing coefficient curves and binding energy per particle, are discussed. (J.W.R.)

**21251** PRESENT STATUS OF ATOMIC MASSES AND RELATED CONSTANTS. Wapstra, A. H. (Instituut voor Kernphysisch Onderzoek, Amsterdam. Oak Ridge National Lab., Tenn.). pp 831-41 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

The contributions to the Third International Conference on Atomic Masses are reviewed. The present status of research on atomic masses and related constants is discussed and suggestions are made for future research. (J.W.R.)

**21252** RECENT RESULTS OF MEASUREMENTS BY THE MINNESOTA 16-INCH MASS SPECTROMETER. Johnson, W. H.; Hudson, M. C.; Britten, R. A.; Kayser, D. C. (Univ. of Minnesota, Minneapolis). pp 793-810 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

Improvements made on the Minnesota 16 inch mass spectrometer are described. Several measurements have been made and results are discussed for some of the fundamental masses as well as higher A values. (J.W.R.)

**21253** MASS MEASUREMENTS WITH THE ARGONNE 100-IN. MASS SPECTROMETER. Stevens, C. M.; Moreland, P. E. (Argonne National Lab., Ill.). pp 673-701 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

Mass measurements were made on the Argonne 100″ mass

spectrometer for hydrogen and deuterium. The features of the instrument and operating technique as used in mass measurement applications are described. All masses were measured using a hydrogen unit mass doublet to calibrate for an unsolved systematic error. Other problems encountered are discussed. The values obtained are: H = 1.007825010 ± 28, D = 2.014101887 ± 27 u. (auth)

**21254** SOLUTION OF THE FADDEEV EQUATIONS FOR THE TRITON PROBLEM USING LOCAL TWO-PARTICLE INTERACTIONS. Malfliet, R. A.; Tjon, J. A. (Univ. of Utrecht). Nucl. Phys., A127: 161-8(1969).

A simple method is described to compute exactly the binding energy (BE) of the ground state of three nucleons in the framework of the Faddeev equations. The two-body potentials used are of the local central Yukawa type. The effect of including repulsion in the two-body forces is also studied, and it is found to be considerable. As a result of this calculation, a value of 8.4 MeV is obtained for the BE of triton. (auth)

**21255** POLARIZATION IN THE ELASTIC SCATTERING OF PROTONS FROM DEUTERONS FROM 11 TO 22.7 MeV. Faivre, J. C.; Garreta, D.; Jungerman, J.; Papineau, A.; Sura, J.; Tarrats, A. (CEN, Saclay, France). Nucl. Phys., A127: 169-76 (1969).

Angular distributions of the proton polarization in p-d elastic scattering were measured at $E_p$ = 11, 14.5, 17.5, 20.15, and 22.7 MeV, in the angular range $\theta_{c.m.}$ = 20 to 155°. At 11, 17.5, and 22.7 MeV the angular range was extended forward by detecting the scattered protons with a 180° magnetic spectrometer, but no evidence was found for negative polarizations at small angles. The positive maximum at $\theta_{c.m.} \approx 130°$ moves slowly backwards with increasing energy; its height increases up to 15 MeV where it saturates at a value of 0.22. The negative minimum at $\theta_{c.m.} \approx 110°$ appears at 17.5 MeV, moves also backwards with a depth increasing linearly with energy. Using the available experimental data, a contour map of the proton polarization in p-d elastic scattering is given in the energy range of 0 to 50 MeV. Excitation curves of the polarization and asymmetry of protons elastically and inelastically (from the 4.43 MeV excited state) scattered from $^{12}C$ at a laboratory scattering angle of 55° were also measured in the energy range of 11 to 20 MeV. (auth)

## Nuclear Properties and Reactions, 6 ≤ A ≤ 19

*Refer also to abstracts 21237, 21247–21251, 21255, 21311, 21313, 21322, 21332, and 21376.*

**21256** (AD–673541) ELASTIC SCATTERING OF $^3He$ FROM $^{12}C$ FROM 18 TO 24 MeV. Warshaw, S. I.; Buffa, A. J.; Barengoltz, J. B.; Brussel, M. K. (Illinois Univ., Urbana. Dept. of Physics). Aug. 19, 1968. Contract N00014-67-A-0305. 38p. CFSTI.

Angular distributions of $^3He$ nuclei elastically scattered from $^{12}C$ were taken at beam energies of 18.6, 20.0, 22.2, and 23.9 MeV and were analyzed with six-parameter local optical model potentials having volume and surface absorption terms. It was found to be impossible to obtain good predictions to the data over the full angular range examined, but sets of optical model parameters which gave good fits to the data below 85° (cm) were obtained. These sets had real well depths clustering around mean values of 75, 130, and 210 MeV. No substantial distinction seemed evident in the quality of the fits between the volume and surface absorption analyses, but perhaps more consistent sets of real well depths were obtained for the surface case. The quality of the fits appeared to improve with higher bombarding energy. (auth) (USGRDR)

**21257** (ZFK–130, pp 21-40) NUCLEAR REACTIONS ON LIGHT NUCLEI. [PART] II. Hodgson, P. E. (Oxford Univ. (England). Nuclear Physics Lab.).

Optical model analyses were performed for (d,d) and (d,p) reactions on $^{14}N$ and $^{16}O$ and (d,n) reactions on $^{24}Mg$. Contributions due to the compound nucleus process were calculated taking into account width-fluctuation corrections. (J.W.R.)

**21258** (ZFK–130, pp 41-57) DEUTERON INDUCED REACTIONS ON CARBON. Stiller, G.; Baldeweg, F.; Klabes, R.; Tesch, S. (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)).

Deuteron-induced reactions on $^{12}C$ and $^{13}C$ were analyzed using the optical model in order to test the validity of direct reaction formalism for the reactions in question. The differential cross sections and extracted spectroscopic factors for elastic scattering, (d,α), (d,n), (d,p), and (d,t) reactions were compared with theoretical values. (J.W.R.)

**21259** (ZFK–130, pp 117-18) (d,p) REACTIONS ON NITROGEN AND SILICON ISOTOPES. Eroe, J.; Czibok, T.; Dolinszky, T.; Hrehuss, G. (Magyar Tudomanyos Akademia Kozponti Fizikai Kutato Intezete, Budapest).

The angular distributions and excitation functions for (d,p) reactions on $^{14}N$ at 1.3 to 2.7 MeV and on $^{28}Si$ and $^{29}Si$ at 1.6 to 2.1 MeV were measured. Attempts to fit the angular distributions for $^{14}N$ and $^{28}Si$ were unsatisfactory. For $^{28}Si$ the DWBA calculation reproduced the general shape of the angular distributions but shifted the first maxima systematically at smaller angles. (J.W.R.)

**21260** (ZFK–130, pp 134-6) INVESTIGATIONS OF NUCLEAR STRUCTURE BY THE DOUBLE-STRIPPING PROCESS. Doenau, F.; Hehl, K.; Riedel, C. (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)); Broglia, R. A.; Federman, P. (Niels Bohr Institutet, Copenhagen (Denmark)).

The reactions $^{16}O(t,p)^{12}O$ and $^{18}O(t,p)^{20}O$ were analyzed using Glendenning's theory in order to account for coherence effects appearing in double stripping. It was found that an admixture of deformed configurations is necessary to explain the observed relative cross sections. The reaction $^{48}Ca(t,p)^{50}Ca$ was analyzed to investigate the structure of $^{50}Ca$. Low-lying $0^+$ and $2^+$ states were calculated using two-body matrix elements of the Hamada–Johnston potential with corrections for core polarization. The results were in good agreement with experimental data. (J.W.R.)

**21261** (ZFK–130, pp 137-9) POLARIZATION OF PROTONS FROM THE REACTION $^{12}C(^3He,p_0)^{14}N$. Kriwopustow, M.; Schirmer, G.; Sisow, I. W.; Oehler, H. (Joint Inst. for Nuclear Research, Dubna (USSR)). (In German).

The polarization of protons from the reaction $^{12}C(^3He,p_0)^{14}N$ was measured using a ring polarimeter, developed from a proposal by Brinkman. The principle of this ring polarimeter is described. The preliminary experimental results obtained are reported and compared with previous measurements made by the left-right asymmetry method. There was agreement between the results of the two methods. (J.S.R.)

**21262** (ZFK–130, pp 140-2) ANGULAR DISTRIBUTION OF PROTONS FROM THE REACTION $^{12}C(^3He,p)^{14}N$. Kriwopustow, M. I.; Sisow, I. W.; Schirmer, G.; Oehler, H. (Joint Inst. for Nuclear Research, Dubna (USSR)). (In German).

The angular distribution of the proton groups $p_0$, $p_1$, and $p_2$ were measured for small intervals. Excitation functions were also measured. Typical results for these two measurements are reported. Resonances in the excitation functions were detected at 2.5, 2.75, and 3 MeV. The 2.75-MeV resonance is noticeable on the $p_1$ groups which are larger than 100°. In the $p_0$ group this resonance gives together with the 3-MeV resonance at large angles a broad peak. This interference is missing in the $p_2$ group. The least square method showed that in addition to the three resonances other states were excited or direct transitions occur for which the orbital moment of rotation is $l \geq 3$. (J.S.R.)

**21263** (ZFK–130, pp 143-4) THE $^6Li(n,t)^4He$ REACTION AT 2.7- AND 14.4-MeV NEUTRON ENERGIES. Rendic, D.; Paic, G. (Institut Rudjer Boskovic, Zagreb (Yugoslavia)).

Triton angular distributions and recoil alpha spectra were measured for the $^6Li(n,t)$ reaction at 2.7 and 14.4 MeV. Possible mechanisms for the reaction are suggested. (J.W.R.)

**21264** (ZFK–130, pp 145-7) INVESTIGATION OF THE REACTION $^3Be + T$. Kim Syn Nam (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Neutron Physics). (In Russian).

A thin, self-supporting $^9Be$ target was used in the experiments, and the reaction products were detected by silicon surface-barrier counters equipped with a 128-channel pulse-height analyzer. At energies of 520 to 1700 keV the absolute differential cross-sections were measured for the reactions: $^9Be(t,\alpha_0)^8Li$, $^9Be(t,\alpha_1)^8Li^*$, $^9Be(t,d)^{10}Be$, $^9Be(t,t)^9Be$ at angles of 70° and 90° in steps of 7 to 10 keV. The total cross-sections of the $^9Be(t,\alpha_0)^8Li$ reactions increase smoothly from 12 mbarns at 519 keV energy to 109 mbarns at 1672 keV energy. The total cross-sections of the $^9Be(t,\alpha_1)^8Li^*$ reaction in the same energy interval vary from 9 to 71 mbarns respectively. The cross-sections of the $^9Be(t,d)^{10}B$ reaction at 70° and 90° angles also increase smoothly with energy. No resonance structure could be detected. (TTT)

**21265** (ZFK–130, pp 148-51) INVESTIGATION OF THE REACTION $^{16}O(n,\alpha)^{13}C$ WITH 14.1-MeV NEUTRONS. Karge, H.; Goetz, G.; Guenther, R.; Mittenbacher, J.; Muehle, R.; Prager, R. (Jena Univ. (East Germany). Technisch-Physikalisches Institut). (In German).

The angular distribution of the $^{16}O(n,\alpha)$ reaction was measured using a cloud chamber. The excitation energy spectrum of $^{13}C$ obtained is shown. The peaks for $\alpha_0$ and $\alpha_1$, corresponding to the transitions to the ground state and the 3.085-MeV level, were well separated. The $\alpha_2$ and $\alpha_3$ groups were not resolved. In the excitation energy range over 4.5 MeV now individual levels could be resolved. The angular distributions for the separated and non-separated groups are given. The results agree with previous studies. The results show that the reaction studied proceeds by a direct reaction. (J.S.R.)

**21266** (ZFK-130, pp 162-4) EXPERIMENTAL ANALYSIS OF THE REACTION $^{14}N(n,2\alpha)^7Li$ AT 14.1 MeV. Schmidt, G.; Moesner, J.; Schintlmeister, J. (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)).

The reaction $^{14}N(n,2\alpha)^7Li$ was studied at 14.1 MeV. Excitation spectra for the formation of $^{11}B$ and $^7Be$ compound nuclei were measured and the cross section for the reaction was determined. (J.W.R.)

**21267** (ZFK-130, pp 165-6) SURFACE CLUSTERING IN $^6Li$. Bang, J. (Niels Bohr Institutet, Copenhagen (Denmark)).

The reduced transition probability for the 2.18-MeV ground-state transition in $^6Li$ was calculated using a Saxon–Woods potential in a combination of shell-model and cluster model wavefunctions. The 2S state was taken as the ground state. The depth of the potential was fitted to the experimental binding energy of the cluster system. A comparison with pure shell-model calculation indicates that the shell-model wavefunction is dominant except at the smaller value of q. (J.W.R.)

**21268** (ZFK-130, pp 168-9) HEAVY ION TRANSFER REACTIONS BETWEEN IDENTICAL STATES. von Oertzen, W.; Bock, R.; Gutbrod, H. H.; Voos, U. (Max-Planck-Institut fuer Kernphysik, Heidelberg (West Germany)).

Heavy-ion transfer reactions of the type A(B,A)B should be very useful in spectroscopic studies due to the identity to elastic scattering states, the localization of the reaction, and the identity of the spectroscopic factors in initial and final states. The angular distributions for the $^{12}C(^{16}O,^{12}C)^{16}O$ reaction were calculated using Dar's diffraction model. The parameters were derived from an optical model analysis of the angular distributions. (J.W.R.)

**21269** (ZFK-130, pp 170-3) INVESTIGATION OF THE $^6Li(^6Li,n)^{11}C$ REACTION WITH A THRESHOLD ENERGY OF 1.9 MeV. Guenther, R.; Goetz, G.; Karge, H.; Mittenbacher, J.; Muehle, R.; Prager, R. (Jena Univ. (East Germany). Technisch-Physikalisches Institut). (In German).

The reaction $^6Li(^6Li,n)^{11}C$ was investigated on the 2-MV Van de Graaff accelerator at Jena. The measurement of the neutron yield and the angular distribution was done by nuclear emulsions. The angular distributions obtained for the transitions to the ground state and to the 1.99, 4.25, and 4.75 MeV state were discussed and compared with the corresponding results of the $^6Li(^6Li,p)^{11}B$ reaction. (tr-auth)

**21270** (ZFK-130, pp 174-7) ON THE $^9Be(^6Li,p)^{14}C$ REACTION. Kaschlik, K.; Koch, H. (Jena Univ. (East Germany). Technisch-Physikalisches Institut).

Proton spectra and angular distributions were measured for the $^9Be(^6Li,p)^{14}C$ reaction at 1.9 MeV. Spin-parity assignments were made for several levels in $^{14}C$. The results are discussed in terms of the statistical model. (J.W.R.)

**21271** (ZFK-130, pp 178) $^6Li + ^{12}C$ REACTIONS. Pfeiffer, K. O.; Bethge, K.; Meier-Ewert, K. (Heidelberg Univ. (West Germany). Zweites Physikalisches Institut).

Angular distributions were measured for lithium-6 reactions $(^6Li,p)$, $(^6Li,d)$, $(^6Li,\alpha)$ and elastic scattering on $^{12}C$ at 20 MeV. Excitation functions were measured at 18 to 20 MeV. An optical model analysis was performed in order to gain information on the reaction mechanisms. (J.W.R.)

**21272** (ZFK-130, pp 186-8) DEFORMED STATES IN $^{16}O$. Jaeger, H.-U.; Muenchow, L. (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)).

Calculations were performed for the low-lying even-parity states in $^{16}O$ using particle–hole wavefunctions with fixed deformation. (J.W.R.)

**21273** (ZFK-130, pp 189) METHOD OF DEFORMED ORBITS APPLIED TO LIGHT NUCLEI. Vashakidze, I. Sh.; Mamasakhlisov, V. I. (Tbilisskii Gosudarstvennyi Universitet (Georgian SSR)). (In Russian).

Levels of light nuclei were calculated by the method of Hartree–Fock which assumes a radial symmetry. A number of light nuclei from A = 18 to A = 27 are deformed in the ground state and in the excited states. For nuclei with an unfilled shell a method of calculating the deformed states was worked out. With the use of this method, the low-lying, bound excited states of nuclei with A = 6, and also the beta decay of the $^6He$ nucleus were calculated. A $^4He$ residue which is not excited was assumed to be surrounded with two peripheral nucleons. Real potentials of the nucleon-nucleon interaction were used. The effect of Coulomb interactions was taken into account in the calculation. The theoretical values agree well with the calculated values. (TTT)

**21274** (ZFK-130, pp 194-5) INVESTIGATION OF THE POSITIVE-PARITY LEVELS IN $^{15}N$. Zhusupov, M. A.; Eramzhyan, R. A. (Joint Inst. for Nuclear Research, Dubna (USSR)). (In Russian).

$^{15}N$ is one of the nuclei whose upper levels may have a parity opposite to that of the ground state. The ground state of the $^{15}N$ nucleus is a hole in the 1 p shell. Levels of opposite parity form configurations in which one nucleon from the 1 p shell has gone to the neighboring 2 s or 1 d shell. A hole in a s-shell is also added to these states. On this basis a diagonalization procedure is carried out as a result of which energy positions and wave functions of the levels are obtained. The results of calculating the higher levels, namely, the states corresponding to a dipole resonance, show that the giant photoabsorption resonance consists of four groups of levels. Information is given on the quantum numbers, the photoabsorption cross-section, reaction channels, etc. It is concluded that ground transitions of $^{15}N$ go to highly excited states of the $^{15}N$ nucleus which are not bound. Secondary particles are emitted. The giant photoabsorption resonance is formed from a group of levels in the region of 24 MeV. (TTT)

**21275** (ZFK-130, pp 196-200) MICROSCOPIC DESCRIPTION OF INELASTIC PROTON SCATTERING FROM (2s,1d)-SHELL NUCLEI. Hoehn, J. (Technische Universitaet, Dresden (East Germany). Institut fuer Experimentelle Kernphysik); Reif, R.; Slotta, J. (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)).

A DWBA analysis was performed for the inelastic scattering of 17.5-MeV protons from $^{16}O$, $^{28}Si$, and $^{32}S$. The investigations were based on a microscopic description using shell model wave functions and assuming a single scattering approximation which leads to an effective two-particle interaction. (J.W.R.)

**21276** (ZFK-130, pp 201-2) POSITIONS AND WIDTHS OF LOW LYING NEGATIVE PARITY STATES IN $^{17}O$. Pfitzner, A. (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)).

Energy levels for $^{17}O$ were calculated using a non-hermitian energy dependent Hamiltonian. For one case a potential of Ripka was chosen to represent the residual interaction, and for another the Kallio–Kolltveit potential was chosen. The largest disagreement with experiments was the position of the $^7/_2$ level. The widths were somewhat small in all cases. (J.W.R.)

**21277** (ZFK-130, pp 222-3) PRODUCTION OF $^8He$, $^8Li$, AND $^8B$ ON CAPTURE OF $\pi^-$ MESONS BY $^{12}C$, $^{14}N$, AND $^{16}O$ NUCLEI. Batusov, Yu. A.; Bunyatov, S. A.; Sidorov, V. M.; Yarba, V. A. (Joint Inst. for Nuclear Research, Dubna (USSR). Lab. of Nuclear Problems). (In Russian).

The capture of slow $\pi^-$ mesons by light C, N and O nuclei was studied in photo-emulsions. There were detected a total of 16 cases of $^8He$ formation, and 18,000 cases of $^8Li$ and $^8B$ formation, which give T-shaped traces in the photoemulsion. The mass of the $^8He$ atom was found to be 31.0 ± 0.4 MeV, which agreed well with theoretical predictions and previous experimental values. It follows from this $^8He$ mass that the binding energy of the tetraneutron should not exceed 3.7 ± 0.4 MeV. The yield of $^8He$ nuclei is $10^{-3}$ of the yield of $^8Li$ and $^8B$ nuclei. The relative probability for the formation of a tetraneutron by reaction of a $\pi^-$ meson on $^{12}C$ was found to be less than $2.6 \times 10^{-6}$ at the 90% confidence level. The set of experimental data agrees with the theory of direct nuclear reaction. (TTT)

**21278** (ZFK-130, pp 226-31) DOPPLER BROADENING OF THE $\gamma$-LINE FROM THE REACTION $^{10}B(n,\alpha)^7Li$ ($\gamma$ 478 keV)$^7Li$. Juna, J. (Ceskoslovenska Akademie Ved, Rez. Ustav Jaderneho Vyzkumu).

An expression for the broadening of $\gamma$ lines from recoil ions due to the relativistic Doppler effect was derived. It is shown that relativistic effects must be considered in extracting lifetimes from Doppler shift measurements. It is further shown that when the recoil ion is in a slowing down medium, either the half-life or the stopping cross section can be deduced. Measurements were performed for the Doppler broadening of the 478 keV $^7Li$ line from the reaction $^{10}B(n,\alpha)^7Li$ using several different target compositions. The mean lifetime of the first excited state in $^7Li$ was determined. (J.W.R.)

**21279** ENERGY LEVELS OF $^{18}F$ FROM $^{16}O(d,d)^{16}O$. Machali, F.; Saleh, Z. A.; Baranik, A. T.; Asfour, F.; Bondouk, I.;

Storizhko, V. E. (Atomic Energy Establishment, Cairo). Ann. Phys. (Leipzig), 21: 1-11(1968).

The differential cross sections for elastic scattering of deuterons from $^{16}O$ were measured in the $E_d$ = 1.0 to 2.5-MeV region at eight scattering angles. Resonances were observed at $E_d$ = 1.00, 1.80 and 2.45 MeV, corresponding to the excited states in $^{18}F$ at 8.40, 9.11, and 9.69 MeV. Analysis of the data in terms of the single-level approximation leads to the assignments $I^\pi = 1^+$, $3^+$ and $2^+$, respectively. Reduced partial widths for elastic scattering were determined. (auth)

**21280** MEASUREMENT OF THE NEUTRON POLARIZATION IN THE REACTION $^{12}C(d,n_0)^{13}N$ USING THE MOTT–SCHWINGER SCATTERING. Brueckmann, H.; Kluge, W.; Schaenzler, L. (Technische Hochschule, Karlsruhe, Ger. Kernforschungszentrum, Karlsruhe, Ger.). Z. Phys., 221: 379-400(1969). (In German).

The polarization of neutrons produced in the reaction $^{12}C(d,n_0)^{13}N$ was measured. Deuterons from the Karlsruhe isochronous cyclotron were used to induce this reaction at 51.5-MeV laboratory energy. The degree of polarization was determined by using the special features of Mott-Schwinger scattering. With a uranium scatterer, analyzing efficiencies of up to 0.92 can be obtained at very small angles (0.23°). The analyzing efficiency can be calculated if the differential cross section at 0° and the total cross section is known. These quantities were experimentally determined. The differential cross section for 49.4-MeV neutrons, scattered by uranium, was measured between 0.88 and 2.10°. By an extrapolation the value 43.4 ± 2.6 b/sr was found for the nuclear differential cross section at zero degree. A total cross section of $\sigma_t$ = 4.80 ± 0.22 b was obtained. The neutron polarization was measured at a reaction angle of 24.5°, and the result is P = −0.45 ± 0.07. This value is fairly above the semiclassical $\frac{1}{3}$ limit and can be only explained, if spin orbit forces are taken into account. For (d,n) reactions this is the first neutron-polarization measurement above an energy of 20 MeV. (auth)

**21281** SEQUENTIAL PROCESSES IN THE $^{14}N(\tau,p\alpha)^{12}C^*$ REACTION. Hofmann, K.; Mausberg, W.; Raabe, M.; Roessle, E.; Tauber, M. (Univ., Freiburg i. B.). Z. Phys., 221: 417-22 (1969).

Alpha-particle and proton spectra in coincidence with the 4.44-MeV $\gamma$ ray from the $^{12}C$ first excited state were taken at $E_\tau$ = 8 MeV. Several states in $^{13}N$ and $^{16}O$ are seen to contribute to the decay sequence $\alpha-p$ and $p-\alpha$, respectively. Estimates are given for the branching of these two decay modes and for a possible simultaneous break-up. (auth)

**21282** INELASTIC ELECTRON SCATTERING FROM $^6Li$ AND $^7Li$. Hutcheon, R. M.; Caplan, H. S. (Saskatchewan Accelerator Lab., Saskatoon). Nucl. Phys., A127: 417-28(1969).

The form factors for the excitation of some of the low-lying states of $^6Li$ and $^7Li$ were measured for momentum transfers up to 1.2 $fm^{-1}$. The results for $^6Li$ are consistent with a p-shell harmonic oscillator parameter of 2.0 ± 0.1 fm. The $^7Li$ data were compared with the collective model predictions of Chesterfield. Reasonable agreement is obtained. Underlying some of the narrow levels, the spectra of both $^6Li$ and $^7Li$ indicate a rather large quasi-continuous cross section starting just above the alpha-deuteron and alpha-triton separation energies, respectively. The "differential" form factors for these continuous cross sections are given. Some spectra of the giant resonance regions of $^6Li$ and $^7Li$ are also presented. (auth)

**21283** Q-VALUES OF (p,n) REACTIONS. Murray, G. (Univ. of Manchester, Eng.); Freeman, J. M.; Jenkin, J. G.; Burcham, W. E. pp 545-65 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

Threshold energies and Q-values were measured for (p,n) reactions with A = 10 to 58 nuclei. The threshold energies measured permitted evaluation of endpoint energies of pure Fermi superallowed beta transitions. The half-lives for these decays were measured and the ft values calculated. (J.W.R.)

**21284** DETERMINATION OF $(n,\gamma)$ REACTION Q-VALUES FROM CAPTURE $\gamma$-RAY SPECTRA. Rasmussen, N. C.; Orphan, V. J.; Hukai, Y. (Massachusetts Inst. of Tech., Cambridge). pp 278-95 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28-September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

Gamma spectra from $(n,\gamma)$ reactions with 75 elements were measured using a Ge(Li) triple coincidence pair spectrometer. Q-values for 56 reactions were determined to an accuracy of ±1 keV. (J.W.R.)

**21285** REACTIONS ON $^{19}F$ INDUCED BY 14.4-MeV NEUTRONS. Antolkovic, B.; Paic, G.; Rendic, D.; Tomas, P.; Turk, M. (Ruder Boskovic Inst., Zagreb. Faculty of Natural Sciences, Zagreb). Izv. Akad. Nauk SSSR, Ser. Fiz., 32: 1658-63(1968). (In Russian).

The energy spectra and angular distributions of charged particles emitted during the interaction of 14.4-MeV neutrons with $^{19}F$ nuclei in the $^{19}F(n,p)^{19}O$, $^{19}F(n,d)^{18}O$, $^{19}F(n,t)^{17}O$, and $^{19}F(n,\alpha)^{16}N$ reactions were investigated using telescope counters and nuclear emulsions. A 5.11 and 3.03 mg $cm^{-2}$ Teflon foil was used as target, the latter especially for the study of the $(n,\alpha)$ reaction. The proton spectrum from the first reaction revealed the existence of 3 proton groups, corresponding to transitions to the ground and first excited (0.94-MeV) states, to the second (1.47-MeV) states and to the next 3-, 2.35-, 2.77-, and 3.16-MeV states. The mean cross section at 120° amounted to 13 mbarn; the integrated proton spectrum from 4 MeV up yielded a cross section of 32 ± 4 mbarn which did not agree with previous results. Data from the $^{19}F(n,d)^{18}O$ reaction agreed with F. L. Ribe's findings. Study of the $^{19}F(n,t)^{17}O$ reaction indicated the existence of 2 separate groups of tritons, arising from the ground and the first excited states of $^{17}O$. In the $(n,\alpha)$ reaction, a high-energy peak corresponding to the ground and the first 3 excited states of $^{16}N$ were found. (TTT)

**21286** SHELL-MODEL CALCULATIONS IN THE CONTINUUM FOR THE REACTION $^{15}N(n,n')^{15}N$ AND THE HUMBLET–ROSENFELD EXPANSION OF THE S-MATRIX. Andersen, B. L.; Ebenhoeh, W. (Univ., Heidelberg). Nucl. Phys., A127: 209-20(1969).

The dependence of the bound and resonance states obtained by a shell-model calculation including the continuum on the strength of the residual interaction was investigated. The S-matrix obtained by this procedure was analyzed in terms of the Humblet-Rosenfeld theory. (auth)

**21287** PROJECTED HARTREE–FOCK CALCULATIONS FOR LIGHT NUCLEI. IV. NORMAL PARITY STATES OF $^9Be$. Bouten, M. (SCK–CEN, Mol, Belg.); Bouten, M.-C.; Depuydt, H.; Schotsmans, L. Nucl. Phys., A127: 177-87(1969).

A projected Hartree-Fock calculation is carried out for the odd-parity states of $^9Be$. The Hamiltonian contains in addition to the two-body interaction of Brink also a one-body spin-orbit force, the strength of which is determined from the condition that the ground-state magnetic moment should be reproduced. Form factors for elastic and inelastic scattering of high-energy electrons are calculated. The satisfactory agreement with experiment suggests that the ground-state quadrupole moment should be between 5.5 and 6 $fm^2$. (auth)

**21288** DEUTERON-INDUCED REACTIONS IN $^{12}C$ AT BOMBARDING ENERGIES OF 5 TO 10 MeV. Cords, H.; Din, G. U.; Robson, B. A. (Australian National Univ., Canberra). Nucl. Phys., A127: 95-115(1969).

Absolute differential cross sections for the reactions $^{12}C(d,p)^{13}C$ leading to the ground state and the 3.09, 3.68, and 3.85 MeV excited states, $^{12}C(d,\alpha)^{10}B$ for the ground state and 0.717 MeV residual level and the elastic scattering of deuterons on $^{12}C$ were measured for bombarding energies of 5 to 10 MeV. An analysis of these measurements was performed using the optical model and the distorted-wave and Hauser-Feshbach theories. (auth)

**21289** GAMMA RAYS FOLLOWING HEAVY-ION BOMBARDMENT OF LIGHT NUCLEI. Nomura, T.; Morinaga, H.; Povh, B. (Max-Planck-Institut fuer Kernphysik, Heidelberg. Univ., Heidelberg). Nucl. Phys., A127: 1-12(1969).

A systematic study of gamma rays from thick targets between $^{12}C$ and $^{28}Si$ bombarded with $^{10}B$, $^{12}C$, $^{14}N$, and $^{16}O$ ions of 16 to 30 MeV was performed with Ge(Li) and NaI(Tl) detectors. Gamma lines from high-spin states populated by the reactions (HI,pn), (HI,$\alpha$p), (HI,2p) and (HI,2$\alpha$) dominate in almost all cases. The excitation functions of the $^{16}O(^{14}N,pn)$, $^{16}O(^{14}N,\alpha p)$, and $^{16}O(^{14}N,2p)$ reactions measured from 16 to 30 MeV can be fairly well understood within the statistical model. The relative intensities of protons, neutrons, and alpha particles emitted from the compound nucleus depend strongly on the bombarding energy, which defines the spin distribution given to the nucleus. (auth)

## Nuclear Properties and Reactions, 20 ≤ A ≤ 89

*Refer also to abstracts 20068, 21012, 21237, 21247, 21248, 21250–21252, 21257, 21259, 21260, 21273, 21275, 21283, 21284, 21289, and 21330.*

**21290** (CEA-R-3572) CONTRIBUTION TO THE STUDY OF TWO NUCLEON TRANSFER REACTIONS. APPLICATION TO THE SPECTROSCOPIC STUDY OF $^{56}$Co. Laget, Jean-Marc (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). 1968. 146p. (In French). Dep. Thesis. Submitted to Univ., Paris.

The different ways of computation of the cross sections for direct two-nucleon transfer reactions are presented. The results are compared to the experimental data on the reactions $^{54}$Fe($^3$He,p) $^{56}$Co at E($^3$He) = 18 MeV and $^{54}$Fe(t,p)$^{56}$Fe at E(t) = 12 MeV. The analysis of the experimental results on the reactions $^{54}$Fe($^3$He,p) $^{56}$Co at E($^3$He) = 18 MeV and $^{54}$Fe(t,p)$^{56}$Fe at E(t) = 12 MeV allow the spectroscopic study of $^{56}$Co. (auth)

**21291** (COO-1608-4) DELAYED PARTICLE SPECTROSCOPY. Technical Progress Report, May 1, 1968-April 30, 1969. Reeder, Paul L. (Washington Univ., St. Louis, Mo.). Jan. 30, 1969. Contract AT(11-1)-1608. 17p. Dep. CFSTI.

Delayed-neutron yields from $^{209}$Bi, $^{232}$Th, and $^{238}$U bombarded by $^3$He and $\alpha$ beams were measured. Delayed-neutron yields and spectra were also measured for the spontaneous fission of $^{252}$Cf. A recoil collection technique was developed to study delayed protons and alpha decay. The alpha decay of $^{212}$At was studied. An attempt is in progress to measure the delayed-proton spectrum for $^{41}$Ti. The $\gamma$ spectra from the decay of $^{42}$Ti was measured. (J.W.R.)

**21292** (ZFK-130, pp 93-5) SPECTROSCOPIC INVESTIGATION OF THE $^{28}$Si NUCLEUS BY THE REACTIONS ($^3$He,d) AND ($^3$He,$\alpha$). Martin, S.; Santo, R. (Max-Planck-Institut fuer Kernphysik, Heidelberg (West Germany)).

Angular distributions were measured for ($^3$He,$\alpha$) reactions with $^{27}$Al and $^{29}$Si and ($^3$He,d) reactions with $^{27}$Al at 15 and 18 MeV using a broad-range magnetic spectrograph and an E-$\Delta$E particle identifier. Energy levels with spin-parity assignments were determined for $^{28}$Si and the Coulomb separation energy for the isobaric pair $^{28}$Al-$^{28}$Si was found. (J.W.R.)

**21293** (ZFK-130, pp 96-9) FINE STRUCTURE OF THE ISOBARIC ANALOG RESONANCE IN THE REACTIONS $^{55}$Mn(p,$\gamma$)$^{56}$Fe AND $^{55}$Mn(p,n)$^{55}$Fe. Otto, G.; Mehnert, R.; Tomaselli, G. (Leipzig Univ. (East Germany). Physikalisches Institut). (In German).

The isobaric analog resonances of the reactions $^{55}$Mn(p,$\gamma$)$^{56}$Fe and $^{55}$Mn(p,n)$^{55}$Fe and the elastic proton scattering on $^{55}$Mn were measured with an energy resolution of $\lesssim$1 keV and target thicknesses of 0.8 or 2.5 keV (for 1 MeV proton energy). The excitation curves of the reactions are given. Both curves show 7 isobaric analog resonances at about the same energies. The resonance energies and the excitation energies of the levels in the $^{56}$Fe nucleus are tabulated. The level scheme of the isobaric analog states found in $^{56}$Fe in connection with the levels of the $^{56}$Mn nucleus is known from (d,p) measurements. The excitation curves show marked fine structure. The fine structure for the 1648-keV resonance is resolved to the background. The natural width of these fine structures is much less than 1 keV. Significant asymmetries also occur. In the study of the photon scattering on $^{55}$Mn it was established that the excitation curve of the proton scattering also shows resonances with fine structures. (J.S.R.)

**21294** (ZFK-130, pp 100-3) INFORMATION ON ISOBARIC ANALOG STATES IN $^{56}$Fe. Otto, G.; Tomaselli, G.; Mehnert, R. (Leipzig Univ. (East Germany). Physikalisches Institut). (In German).

The curve forms of the isobaric analog resonances measured in the reactions $^{55}$Mn(p,$\gamma$)$^{56}$Fe and $^{55}$Mn(p,n)$^{55}$Fe were fitted by the Robson and Breit-Wigner methods, and the values obtained for the resonance width $\Gamma$ and the level displacement parameter $\Delta$ were compared with each other. The results obtained for both the Robson and Breit-Wigner fits were tabulated and show that good agreement was obtained in spite of the asymmetrical resonance form. The resonance at 1415 keV show a completely different form in the two excitation curves. A comparison is made of the cross section of the (d,p) reaction on $^{55}$Mn with the resonance yields of the (p,$\gamma$) and (p,n) reactions. The resonance intensities show a similar behavior in all reactions. (J.S.R.)

**21295** (ZFK-130, pp 108-9) ANALOG TRANSITIONS OBSERVED IN THE $^{42}$Ca($^3$He,$\alpha$) REACTION AND SPIN ASSIGNMENTS TO $^{42}$K LEVELS. Lynen, U.; Bock, R.; Santo, R.; Stock, R. (Max-Planck-Institut fuer Kernphysik, Heidelberg (West Germany)).

Angular distributions were measured for the $^{42}$Ca($^3$He,$\alpha$) reaction at $^{18}$MeV using a broad-range magnetic spectrograph. At excitation energies beyond $^7$MeV analogous levels of $^{42}$K were expected and 7 such resonances were observed. Spin-parity assignments were made for the low-lying levels in $^{42}$K assuming pure seniority-one configuration for the neutrons. (J.W.R.)

**21296** (ZFK-130, pp 111-15) THE STUDY OF (d,p) REACTION ON $^{49}$Ti AND $^{50}$Ti NUCLEI. Grotowski, K.; Jasielska, A.; Panek, T.; Pellegrini, F.; Wiktor, S. (Institute of Nuclear Physics, Krakow (Poland)).

The angular distribution of protons from (d,p) reactions on $^{48}$Ti and $^{50}$Ti at $E_d$ = 12.9 MeV was measured in 5° intervals from 20 to 105°. Several levels in $^{49}$Ti and $^{51}$Ti were observed with a new level at 3.80 MeV in $^{49}$Ti being identified. The measured angular distributions were fitted with a DWBA zero-range calculation and spectroscopic factors were calculated and compared with other values. (J.W.R.)

**21297** (ZFK-130, pp 119-20) NUCLEAR STRUCTURE STUDIES BY DEUTERON-INDUCED REACTIONS ON $^{38}$Ar AND $^{40}$Ar. Fitz, W.; Jahr, R.; Santo, R. (Max-Planck-Institut fuer Kernphysik, Heidelberg (West Germany)).

The angular distributions were measured for deuteron elastic and inelastic scattering and (d,p) and (d,t) reactions on $^{38}$Ar and $^{40}$Ar at $E_d$ = 11.6 MeV. The angular distributions were fitted by a DWBA calculation and spectroscopic factors were determined for levels in $^{39}$Ar and $^{41}$Ar. (J.W.R.)

**21298** (ZFK-130, pp 121-5) (d,d) AND (d,p) REACTIONS ON $^{24}$Mg. Der, R.; Fuelle, R.; Netzband, D.; Schlott, K. (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)).

The angular distributions were measured for the reaction $^{24}$Mg(d,p) at 13.5 MeV leading to ten low-lying states in $^{25}$Mg. In addition angular distributions were measured for deuteron elastic scattering by $^{24}$Mg at 13.5 MeV. A parameter search program was run in order to find the parameters needed in an optical model analysis. Spectroscopic factors were extracted using DWBA and Butler's theory. (J.W.R.)

**21299** (ZFK-130, pp 126-30) PRELIMINARY RESULTS ON CORRELATION MEASUREMENTS FOR THE REACTION $^{24}$Mg(d,p$\gamma$)$^{25}$Mg(3.40 MeV). Der, R.; Fuelle, R.; Netzband, D.; Schlott, K. (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)). (In German).

Angular correlation measurements were made on the transition to the 3.40-MeV level in order to determine whether it is possible to describe with a single parameter angular distributions and angular correlations. The parameter theorems obtained from the optical model analysis, the Rosen parameter, and from the 6-parameter fit on the experimental angular distribution are given, and the angular distribution calculated is shown. The distribution with the parameter theorem from the 6-parameter fit describes the experimental distribution very well. No satisfactory agreement between experimental and calculated results was obtained for the angular correlations. (J.S.R.)

**21300** (ZFK-130, pp 131-2) TWO-STEP PROCESS IN THE REACTION $^{42}$Ca(d,p$_1$)$^{43}$Ca. Barz, H. W. (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)).

Differential cross sections were measured for deuteron elastic and inelastic scattering and (d,p) reactions on $^{42}$Ca leading to the first excited state in $^{43}$Ca for $E_d$ = 7.2 and 7.5 MeV. The transition matrix elements were calculated as a sum of a direct and a two-step process. (J.W.R.)

**21301** (ZFK-130, pp 152-4) DIFFERENTIAL ELASTIC AND INELASTIC SCATTERING OF 14.8-MeV NEUTRONS FROM $^{28}$Si. Hoehn, J.; Pose, H.; Seeliger, D.; Seidel, K. (Technische Universitaet, Dresden (East Germany). Institut fuer Experimentelle Kernphysik).

Differential cross sections for neutron elastic and inelastic scattering by silicon-28 at 14.8 MeV were measured using a time-of-flight spectrometer. Excitation of several levels in $^{28}$Si were observed. An optical model analysis was performed for the data. (J.W.R.)

**21302** (ZFK-130, pp 155-7) SCATTERING OF POLARIZED PROTONS ON SELENIUM. Deutscher, M.; Heinrich, G.; Hentschel, E. (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)).

The asymmetry in the elastic scattering of 6.5-MeV protons by $^{80}$Se was measured using a Si(Li) detector. The results were compared with an optical model calculation using the average potential of Rosen and a wide disagreement was found. (J.W.R.)

**21303** PHOTOPROTONS FROM YTTRIUM AND ZIRCONIUM. Shoda, Katsufusa (Tohoku Univ., Sendai); Taneichi, Hiroshi. J. Phys. Soc. Jap., 26: 217-25(Feb. 1969).

Energy and angular distributions of photoprotons from natural targets of Y and Zr irradiated with bremsstrahlung were measured with nuclear emulsions. The energy distributions show similar structures to those observed for lighter nuclei. The

gross structures of the energy distributions and the angular distributions suggest important contribution of photoproton groups leaving the residual nuclei in hole states to these (γ,p) reactions. The (γ,p) cross section for either target does not show any correspondence to the (γ,n) giant resonance but shows a gross resonance around 21.5 MeV. The separation of these two resonances is about 5 MeV, which can be explained by the isobaric spin splitting effect. (auth)

**21304** MEASUREMENT OF AVERAGE FISSION NEUTRON CROSS SECTIONS FOR (n,p) REACTIONS OF TITANIUM BY ACTIVATION METHOD. Son, M. S.; Kim, H. J.; Bak, H. I. (Atomic Energy Research Inst., Seoul). J. Korean Phys. Soc., 1: 51-8(Oct. 1968).

Recently many reports have been published on cross-section data for the reactions $^{46}Ti(n,p)^{46}Sc$, $^{47}Ti(n,p)^{47}Sc$, and $^{48}Ti(n,p)^{48}Sc$. The data, however, show large discrepancies among the results of different investigators. In this work activation analysis for titanium was carried out to determine the average fission neutron cross sections using nickel as a reference fast flux monitor. Titanium sponge and nickel foil were irradiated at the midpoint of the central thimble of the Triga-Mark II reactor, and the activities were measured with a 3 in. × 3 in. NaI(Tl) scintillation spectrometer. The absolute activities were evaluated using the photopeak efficiencies of the crystal for each gamma energy; and the measured cross sections with standard error are 11.4 ± 0.9, 19.7 ± 1.0, and 0.28 ± 0.02 mb for the reactions $^{46}Ti(n,p)^{46}Sc$, $^{47}Ti(n,p)^{47}Sc$, and $^{48}Ti(n,p)^{48}Sc$, respectively. The fast neutron flux distribution along the vertical axis of the core was also measured by using these nickel and titanium detectors, and the results are discussed in connection with the application of threshold detectors for the measurement of fast neutrons in a reactor. (auth)

**21305** THE INELASTIC SCATTERING OF ELECTRONS WITH EXCITATION OF THE FIRST $2^+$ STATES OF $^{58}Ni$ AND $^{64}Ni$. Afanas'ev, V. D.; Afanas'ev, N. G.; Gul'karov, I. S.; Savitskii, G. A.; Khvastunov, V. M.; Shevchenko, N. G.; Khomich, A. A. (Kharkov State Univ. Physical-Technical Inst., Kharkov). Ukr. Fiz. Zh., 13: 1919-21(Nov. 1968). (In Russian).

The charge distribution parameters become increasingly important in the inelastic scattering processes of high-energy electrons as the transferred energy becomes larger; this makes it possible to select the most suitable distribution model. Examination of the proposed nuclear excitation models requires the measurement of the form factors within and beyond the minimum of diffraction. Such a study was carried out on a 300-MeV linear accelerator, using 150- and 225-MeV electrons at a scattering angle range from 40 to 95°. The experimental data on the dependence of the form factors on the transmitted pulse were interpreted by means of the high-energy approximation method, assuming that a spherically symmetric Fermi-type charge distribution prevails in the nucleus at the ground state. The low-level collective states excited in the nucleus may be considered as oscillations of the surface about the equilibrium form, as the sphericity is conserved during the excitation. The induced B(E2) transition probability parameters of $^{58}Ni$ and $^{64}Ni$ were tabulated. The observed divergence between the experimental and theoretical data indicates that the nuclear excitation model is not completely satisfactory. The agreement is improved if it is assumed that an equilibrium deformation takes place, leading to a smoothing of the diffraction minimum. (TTT)

**21306** ANGULAR DISTRIBUTIONS IN THE REACTION $^{41}K(p,\alpha_0)^{38}Ar$ AT $E_p$ = 1550 to 2000 keV. Anttila, A.; Bister, M.; Luukko, A. (Univ. of Helsinki). Ann. Acad. Sci. Fenn., Ser. A VI, No. 303, 12p.(1968).

The excitation function of the $^{41}K(p,\alpha_0)^{38}Ar$ reaction was measured at proton energies of 1550 to 2000 keV with simultaneous recording of the $^{41}K(p,n)^{41}Ca$ and $^{41}K(p,\gamma)^{42}Ca$ reactions; 57 $(p,\alpha_0)$ resonances were observed. The angular distributions of alpha particles were measured at 36 resonances. The distribution analysis allowed unique spin for 16 cases. The formation and population parameters for the resonance levels were determined. (auth)

**21307** DECAY CHARACTERISTICS OF SHORT-LIVED RADIONUCLIDES STUDIED BY ON-LINE ISOTOPE SEPARATION TECHNIQUES. Hansen, P. G. (Univ. of Aarhus, Denmark); Hornshoej, P.; Nielsen, H. L.; (and others). Phys. Lett., 28B: 415-19(Jan. 6, 1969).

Short-lived isotopes of argon, krypton, silver, cadmium, tin, iodine, xenon, platinum, gold, mercury, polonium, radon, and francium were studied by the on-line isotope separator technique. Nuclear decay data are presented. (auth)

**21308** ATTEMPT TO DETERMINE THE ORBITAL MOMENT OF THE RESONANCE INDUCED IN $^{56}Fe$ BY NEUTRONS OF ENERGY NEAR 1.15 keV. Alix, Michel; Michaudon, Andre; Tellier, Henry (CEN de Saclay, Gif-sur-Yvette, France). Compt. Rend., Ser. A, B, 268: 345-8(Jan. 27, 1969). (In French).

The resonance induced in $^{56}Fe$ by neutrons with an energy of about 1.15 keV was studied by measuring the transmission of a sample of natural iron for neutrons of that energy. The formal analysis of this resonance shows that its orbital moment is not zero. These results compared with those of other laboratories very probably permit the value of l = 1 to be assigned to it. (tr-auth)

**21309** INTENSITIES AND ENERGIES OF THE γ RAYS IN THE REACTION Rb(n,γ)Rb. Irigaray, Jean-Leon; Petit, Georges-Yves; Samama, Roland; Carlos, Pierre; Girard, Jean; Perrin, Ginette (CEN, Bordeaux. CEN de Saclay, Gif-sur-Yvette, France). Compt. Rend., Ser. A, B, 167: 1358-61(Dec. 16, 1968). (In French).

The separation energy of the neutron in $^{86}Rb$ was determined, and an excitation energy level scheme was proposed. The first excited states agree with a coupling between a proton hole in the subshell Z = 38 and a neutron hole in the shell N = 50. The de-excitation of the capture subshell suggests a spin of 3 and a negative parity for this level. (tr-auth)

**21310** STUDY OF THE DECAY $^{111}Sn \rightarrow {}^{111}In$. Rivier, Janine; Moret, Roger (Institut des Sciences Nucleaires, Grenoble, France). Compt. Rend., Ser. A, B, 268: 349-52(Jan. 27, 1969). (In French).

Study of the decay $^{111}Sn \rightarrow {}^{111}In$ allows one to show new transitions in the de-excitation of $^{111}In$ and to determine the characteristics of the decay scheme for electron capture of $^{111}Sn$ ending in various excited levels of $^{111}In$. (tr-auth)

**21311** NEW NUCLIDES $^{19}Na$ AND $^{23}Al$ OBSERVED VIA THE $(p,^6He)$ REACTION. Cerny, Joseph; Mendelson, R. A. Jr.; Wozniak, G. J.; Esterl, John E.; Hardy, J. C. (Univ. of California, Berkeley). Phys. Rev. Lett., 22: 612-15(Mar. 24, 1969).

By employing the reactions $^{24}Mg(p,^6He)^{19}Na$ and $^{28}Si(p,^6He)^{23}Al$ [$d\sigma/d\Omega \sim 100$ nb/sr], the mass excesses of $^{19}Na$ and $^{23}Al$ are found to be 12.974 ± 0.070 and 6.766 ± 0.080 MeV, respectively [$^{12}C = 0$]. Since $^{19}Na$ is determined to be proton unstable, $^{23}Al$ should be the lightest, nucleon-stable member of the A = 4n + 3, $T_Z = -3/2$ mass series. (auth)

**21312** METASTABLE EXCITED STATE IN $^{184}W$. Monnand, Edouard; Blachot, Jean (CEN, Grenoble, France). Compt. Rend., Ser. A, B, 268: 578-80(Feb. 17, 1969). (In French).

A metastable state in $^{184}W$, fed by the decay of 8.7-hr $^{184}Ta$, was observed. The half-life of this state was measured to be $T_{1/2}$ = 8.0 ± 0.4 μsec. (tr-auth)

**21313** STATES AT 10 TO 14 MeV EXCITATION IN $^{20}Ne$ FROM THE (d,n) REACTION. Ritter, R. C.; Parson, J. T.; Bernard, D. L. (Univ. of Virginia, Charlottesville). Phys. Lett., 28B: 588-9(Mar. 3, 1969).

In using the $^{19}F(d,n)^{20}Ne$ reaction at 5.1 MeV to study states of 10.5- to 13.9-MeV excitation, $l_p = 0$ transitions are observed which, with a few lower states, seem to expend the 2s strength expected for $^{20}Ne$. (auth)

**21314** CROSS SECTION FOR $^{24}Mg(\gamma,n)^{23}Mg$ AND $^{24}Mg(\gamma,2n)^{22}Mg$ REACTIONS. Anderson, D. W.; Cook, B. C.; Englert, T. J. (Ames Lab., Iowa). Nucl. Phys., A127: 474-80(1969).

The sum of the cross sections for the reactions $^{24}Mg(\gamma,n)^{23}Mg$ and $^{24}Mg(\gamma,2n)^{22}Mg$ was measured from threshold to 62 MeV using least structure analysis of the bremsstrahlung yield curve. Maxima in the cross section appear at 19.2 ± 0.3, 21.1 ± 0.3, 25.4 ± 0.4, 35.6 ± 0.7, and 56.7 ± 0.6 MeV. The cross sections integrated to 62 MeV are 172 ± 14 MeV · mb. (auth)

**21315** STUDY OF EXCITED STATES OF $^{40}Ca$ AND $^{48}Ca$ BY THE $(p,p'\gamma)$ REACTION AT $E_p$ = 12 MeV. Tellez, A.; Ballini, R.; DeLaunay, J.; Fouan, J. P. (Centre d'Etudes Nucleaires, Saclay, France). Nucl. Phys., A127: 438-48(1969).

Several previously unobserved levels of $^{40}Ca$ and $^{48}Ca$ were identified by $p'-\gamma$ coincidences; the decay schemes of some of them were deduced. Angular distributions of inelastically scattered protons on $^{48}Ca$ were measured and fitted with the DWBA code JULIE. The 5.15-MeV level of $^{48}Ca$ is probably the first $5^-$ state in this nucleus. The excitation energy and gamma decay of the 7.40- and 7.68-MeV levels of $^{40}Ca$ correspond to that of the expected $6^+$ term of the rotational band 3.35 ($0^+$), 3.90 ($2^+$), 5.27 ($4^+$). (auth)

**21316** CIRCULAR POLARIZATION MEASUREMENTS WITH A Ge(Li) DETECTOR. Kopecky, J.; Warming, E. (AEK Research Establishment, Risoe, Denmark). Nucl. Phys., A127: 385-98(1969).

The results obtained in measurements of the degree of circular polarization of gamma transitions to bound states of $^{32}S$, $^{36}Cl$, $^{49}Ti$, $^{56}Mn$, $^{57}Fe$, $^{60}Co$, and $^{64}Cu$ following the capture of polarized ther-

mal neutrons are given. Spin values were determined on the basis of these results. (auth)

**21317** DECAY OF $^{61}$Cu: ENERGY LEVELS OF $^{61}$Ni. Ritter, J. C.; Larson, R. E. (Naval Research Lab., Washington, D. C.). Nucl. Phys., A127: 399-411(1969).

The decay of $^{61}$Cu was studied using a 5 cm$^3$ Ge(Li) 7.6 cm × 7.6 cm NaI coincidence spectrometer and a 30 cm$^3$ Ge(Li) detector. A total of 31 gamma rays was observed. Decays from ten levels in $^{61}$Ni were observed at 67.20 ± 0.14, 283.63 ± 0.17, 655.96 ± 0.15, 908.85 ± 0.30, 1099.62 ± 0.30, 1131.76 ± 0.45, 1185.22 ± 0.22, 1609.92 ± 0.030, 1729.59 ± 0.25 and 2124.8 ± 1 keV. A possible level is also suggested at 1997 keV. The linearity of the Ge(Li) spectrometer system was studied by observation of the gamma rays emitted in the decay of $^{147}$Nd. This study also yielded precision energy measurements for the $^{147}$Nd gamma rays. Relative intensity measurements for the gamma rays involved in the $^{61}$Cu decay are also given. The half-life of $^{61}$Cu was measured as 204.5 ± 0.6 min. Coincidence measurements were performed to establish the placement of the stronger gamma rays observed in the decay. The proposed decay scheme for $^{61}$Cu is presented, discussed and compared with other recent Ge(Li) measurements. (auth)

**21318** INVESTIGATION OF THE $^{43}$Ca($^3$He,$\alpha$)$^{42}$Ca AND $^{41}$K(d,p)$^{42}$K REACTIONS. Lynen, U.; Oeschler, H.; Santo, R.; Stock, R. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Nucl. Phys., A127: 343-52(1969).

The $^{43}$Ca($^3$He,$\alpha$) reaction was measured at 18 MeV. A large number of configuration states as well as eight analogue states were identified in $^{42}$Ca. Their parent states were investigated in a $^{41}$K(d,p)$^{42}$K experiment at 12 MeV. Spin assignments for some levels in $^{42}$K are discussed. The spectroscopic factors are compared with shell-model calculations of Dieperink and Brussaard. (auth)

**21319** FORMATION AND DECAY OF THE COMPOUND NUCLEUS $^{68}$Ge. II. CALCULATION; COMPETITION BETWEEN GAMMA-RAY AND PARTICLE EMISSION. Ruddy, F. H. (Simon Fraser Univ., Burnaby, British Columbia); Pate, B. D.; Vogt, E. W. Nucl. Phys., A127: 323-42(1969).

The statistical theory of nuclear reactions was used to calculate cross sections for a number of nuclear reactions proceeding through the compound nucleus $^{68}$Ge. The target projectile pairs were $^4$He + $^{64}$Zn, $^{12}$C + $^{56}$Fe and $^{16}$O + $^{52}$Cr; a maximum of two emitted particles was considered. The calculations were performed with an IBM 360/40 computer according to a formalism containing the explicit dependence of particle-emission probabilities on nuclear angular momentum. Probabilities for $\gamma$-ray emission were calculated according to the single-particle model modified to reflect experimentally observed collective effects. Agreement between experiment and calculation was found to be good for $^{64}$Zn + $^4$He excitation functions over the entire energy range studied experimentally. Agreement in the $^{56}$Fe + $^{12}$C case was encouraging considering the complexity of the target-projectile system and attendant theoretical difficulties. (auth)

**21320** FORMATION AND DECAY OF THE COMPOUND NUCLEUS $^{68}$Ge. I. EXPERIMENT AND THE INDEPENDENCE HYPOTHESIS. Ruddy, F. H.; Pate, B. D. (Simon Fraser Univ., Burnaby, British Columbia). Nucl. Phys., A127: 305-22(1969).

In order to investigate the effects of varying angular momentum on the decay of compound nuclei, the compound nucleus $^{68}$Ge was produced by bombardment with $^4$He, $^{12}$C and $^{16}$O ions. To detect any direct interaction component in the reaction mechanism, recoiling product-nucleus ranges were measured in the $^4$He case. With the exception of bombardments at energies above 30 MeV in the ($\alpha$,pn) reaction, it may be concluded that the ($\alpha$,p), ($\alpha$,n), ($\alpha$,2n), and ($\alpha$,pn) reactions proceed predominantly via a compound nucleus mechanism. Comparisons of the alpha-induced and $^{12}$C-induced excitation functions are discussed in terms of angular momentum effects. (auth)

**21321** ENERGY DEPENDENCE OF LEVEL DENSITIES IN THE A = 30 TO 65 MASS RANGE. Vonach, H.; Hille, M. (Technische Hochschule, Munich). Nucl. Phys., A127: 289-304(1969). (In German).

The available information on the level density at low excitation energy and at the neutron binding energy is combined to determine experimentally both the level density parameter a and the energy shift $\Delta$ between the actual ground state and the fictive ground state of the Fermi gas model. Contrary to the widely used shifted Fermi gas model, it is found that the $\Delta$-values for doubly even nuclei are approximately zero, and that the fictive ground states of odd-mass and odd nuclei are negative by about one and two times the pairing energy $\Delta$ as determined from odd-even mass differences. The changes introduced into statistical model-calculations by using the back-shifted Fermi gas model instead of the conventionally shifted Fermi gas model are discussed. (auth)

**21322** CROSS SECTIONS OF THE REACTIONS $^{12}$C → $^{11}$C, $^{63}$Cu → $^{62}$Cu, $^{27}$Al → $^{24}$Na, $^{28}$Si → $^{24}$Na, $^{31}$P → $^{24}$Na, $^{63}$Cu → $^{58}$Co INITIATED BY PHOTONS AND ELECTRONS WITH ENERGIES UP TO 260 MeV. Noga, V. I.; Ranyuk, Yu. N.; Sorokin, P. V. (Physical-Technical Inst., Kharkov). Ukr. Fiz. Zh., 13: 2003-7(Dec. 1968). (In Russian).

The reactions $^{12}$C → $^{11}$C, $^{63}$Cu → $^{62}$Cu, $^{27}$Al → $^{24}$Na, $^{28}$Si → $^{24}$Na, $^{63}$Cu → $^{58}$Co, $^{31}$P → $^{24}$Na were studied by the activation method in the energy range of electrons and protons from 80 to 260 MeV. The targets were activated directly by the electron beam. The use of the targets as sandwiches allowed the processes of photo- and electroactivation to be separated and the cross sections of photo- and electroprocesses to be obtained. The shape of the reaction cross section of energy indicates the presence of a photo-mesonic mechanism in photon absorption. The ratio of yields for nuclear photo- and electrodisintegration is constant in the investigated interval and is equal to 40 ± 5. (auth)

**21323** COUPLED-VIBRATION MODEL FOR EVEN NUCLEI IN THE sd-SHELL. Castel, B. (Queen's Univ., Kingston, Can.); Svenne, J. P. Nucl. Phys., A127: 141-8(1969).

The existence in $^{28}$Si of prolate and oblate intrinsic states is shown by Hartree-Fock calculations. The model proposed here describes two vibrations, one about each of these HF minima, coupled through their quadrupole fields. This model predicts the intermediate energy spectrum of $^{28}$Si in good agreement with the observed levels. Furthermore, the known transition rates are consistent with this simple model. (auth)

**21324** INDIVIDUAL TRANSITIONS IN (n,$\alpha$) REACTIONS AT 14.6 MeV. Spira, C.; Robson, J. M. (Univ. of Ottawa). Nucl. Phys., A127: 81-94(1969).

Cross sections for transitions leading to individual states in the residual nucleus of (n,$\alpha$) reactions initiated by 14.6-MeV neutrons, were measured for the eight isotopes $^{47}$Ti, $^{56}$Fe, $^{58}$Ni, $^{59}$Co, $^{60}$Ni, $^{61}$Ni, $^{63}$Cu, and $^{64}$Zn. The alpha-particle spectra were obtained by using a counter telescope consisting of two transmission proportional counters in front of a lithium-drifted silicon detector. The experimental data were compared with the predictions of two versions of the statistical theory and with a simple pick-up model. The relative trend of the cross sections is in agreement with the predictions of the simple pick-up model. (auth)

**21325** DECAY CHARACTERISTICS OF TWO 3$^-$ STATES IN $^{86}$Sr. Ramayya, A. V. (Vanderbilt Univ., Nashville); Hamilton, J. H.; Deye, J. A.; Robinson, R. L.; Pinajian, J. J. Nucl. Phys., A127: 60-4(1969).

The two lowest 3$^-$ states in $^{86}$Sr exhibit very different decay properties. The lower state, $3_1^-$, decays predominantly to the $2_2^+$ state whereas the $3_2^-$ state decays preferentially to the $2_1^+$ state. The data suggest that B(E3 : $3_1^-$ → 0) is significantly larger than B(E3 : $3_2^-$ → 0) so that the $3_1^-$ state probably arises from octupole vibrations of the nucleus. (auth)

**21326** STUDY OF THE FLUCTUATIONS IN THE $^{25}$Mg(d,$\alpha$)$^{23}$Na REACTION. Ali, M. A.; Bakr, M. H. S.; Omar, H. M.; Storizhko, V. E. (Atomic Energy Establishment, Cairo). Ann. Phys. (Leipzig), (7), 21: 321-31(1968).

The reaction $^{25}$Mg(d,$\alpha$)$^{23}$Na was studied at bombarding energies between 1.5 and 2.5 MeV. Excitation functions for the ground and the lowest six excited states were measured at laboratory angles of 120, 140, and 160°. The energy resolution in the measurements was better than 10 keV. Fluctuations in these cross sections were analyzed on the basis of the Ericson theory. The coherence width of the compound nucleus $^{27}$Al (with excitation energy 19 MeV) averaged over all transitions was found to be 29 keV. From the analysis of the probability distributions of fluctuations, the number of independent magnetic substates was found to be less than that predicted by the theory. Numerous group-cross correlation functions for (d,p) and (d,$\alpha$) reactions on $^{25}$Mg were analyzed. (auth)

**21327** E2 TRANSITIONS IN DOUBLY EVEN sd-SHELL NUCLEI. Grawe, H.; Lieb, K. P. (Univ., Freiburg i. B.). Nucl. Phys., A127: 13-32(1969).

The first $J^\pi = 2^+$ states of some doubly even nuclei in the sd shell were excited in $\alpha$-particle-induced reactions. From the Doppler broadened and shifted line shape of the subsequent $\gamma$-ray transitions, the lifetimes for the levels were determined. (auth)

**21328** THE ALDERMASTON–COPENHAGEN NUCLEAR REACTIONS PROGRAM. Hansen, Ole (Univ. of Copenhagen). pp 527-44 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

A survey is presented of the ground-state Q-values obtained for various nuclear reactions. Sum rules for one-nucleon transfer reactions are discussed. The systematics of excited $O^+$ states near N = 30, relevant to the structure of ground states, are discussed. (J.W.R.)

**21329** COULOMB DISPLACEMENT ENERGIES AND NUCLEAR MASSES. Jaffe, A. A. (Hebrew Univ., Jerusalem). pp 609-21 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

A brief review is presented on the experimental determination of isobaric analog states is given and Coulomb displacement energies of about 50 pairs of states are tabulated. The prediction of nuclear masses through knowledge of analog energy levels is discussed and some predictions of mass excesses are compared with experimental values. (J.W.R.)

## Nuclear Properties and Reactions, A ≥ 90

*Refer also to abstracts 19998, 21237, 21247, 21248, 21250, 21251, 21252, 21284, 21291, 21303, 21307, 21329, 21384, 21393, 21552, and 21609.*

**21330** (COO–1167-6) TECHNICAL PROGRESS REPORT ON NUCLEAR CHEMISTRY RESEARCH, DECEMBER 15, 1967–DECEMBER 15, 1968. Sugarman, Nathan; Turkevich, Anthony (Chicago Univ., Ill. Enrico Fermi Inst. for Nuclear Studies). Contract AT(11-1)-1167. 11p. Dep. CFSTI.

Research progress is reported on the following topics: production of heavy nuclides in the 440-MeV fission of uranium; $^{65}$Zn, Ni, Cu, and Zn contents of Bogou iron meteorites; radionuclide production cross sections in copper with 90 to 440 MeV protons; radiochemical analysis of freshly fallen meteorites; meson spallation of copper; high-energy fission of bismuth and tantalum; amounts of heaviest elements in returned lunar material; recoil studies of isomeric nuclides; evidence for a $(p,p\alpha)$ spallation reaction; production of heavy nuclides from uranium by multi-GeV protons, and a germanium-lithium detector for gamma spectroscopy. (M.C.G.)

**21331** (MIT–952-5(Pt.1), pp 200-314) NUCLEAR PHYSICS. (Massachusetts Inst. of Tech., Cambridge. Dept. of Physics).

Measurements of total internal conversion coefficients for transitions from the first $2^+$ excited states to the $0^+$ ground states in the rotational nuclei $^{224}$Ra, $^{228}$Th, $^{234}$U, and $^{236}$U, and in the vibrational nuclei $^{220}$Rn and $^{222}$Rn are described in detail. Measurements of line shapes of Compton-scattered $\gamma$ rays are outlined, as are measurements of differential elastic scattering cross sections for 662-keV $\gamma$ rays. Efforts at fabrication of large-volume Ge(Li) detectors are summarized, and a four-channel $\alpha$ scintillation counter is described. An experimental investigation of the multiple scattering of $\alpha$ rays is outlined. A modular ferrite core memory system for nuclear data acquisition and processing is described, as is a multichannel dekatron scaler/count rate meter recording system for area radiation monitoring. (D.C.W.)

**21332** (ORO–3820-1) ON-LINE ALPHA AND PROTON DECAY SPECTROMETRY. Progress Report. Macfarlane, Ronald D. (Texas Agricultural and Mechanical Univ., College Station). Jan. 15, 1969. Contract AT(40-1)-3820. 31p. Dep. CFSTI.

The $\beta$-delayed $\alpha$ decay of $^{24}$Al, $^{8}$Li, $^{12}$N, and $^{20}$Na was investigated. An unsuccessful search for $^{106}$Te was conducted by $\alpha$ spectrometry; an $\alpha$ spectrum for $^{107}$Te was obtained. The $\alpha$ decay of $^{216}$Ac, $^{215}$Ra, $^{211}$Ra, $^{217}$Th, and $^{221}$Th was observed; $\alpha$ energies and half-lives were determined. Alpha spectra of products produced in the evaporation of an $^{221}$Ac compound nucleus were recorded. A helium gas flow system for the collection of recoil activities was developed. (D.C.W.)

**21333** (ZFK–130, pp 83-91) SINGLE PARTICLE STATES IN GADOLINIUM NUCLEI. Tjoem, P. O. (Oslo Univ. (Norway). Fysisk Institutt).

Energies of the band heads for Nillson states observed in odd-A gadolinium isotopes were determined from (d,p) and (d,t) reactions. Angular distributions are presented for $^{156}$Gd and $^{160}$Gd(d,t) reactions at $E_d$ = 12 MeV. A level scheme for $^{155}$Gd is proposed. (J.W.R.)

**21334** (ZFK–130, pp 104-7) DETERMINATION OF THE SPIN OF ANALOGUE STATES BY MEASURING THE POLARIZATION OF ELASTICALLY SCATTERED PROTONS. Grosse, E. (Max-Planck-Institut fuer Kernphysik, Heidelberg (West Germany)).

Excitation functions were determined for the elastic scattering of polarized protons by neodymium-142 at 9 to 11 MeV. The low-lying isobaric analog states in promethium-143 were observed and spin-parity assignments were made. (J.W.R.)

**21335** (ZFK–130, pp 233-8) FAST NEUTRON EXCITATION OF ISOMERIC ACTIVITIES IN $^{112}$In AND $^{114}$In ISOTOPES. Kozlowski, T.; Moroz, Z.; Kurarz, E.; Wojtkowska, J. (Institute of Nuclear Research, Swierk (Poland)).

Activation cross sections were measured for (n,2n) reactions on $^{113}$In and $^{115}$In at 14.7 MeV. In addition the cross section for inelastic scattering on $^{113}$In leading to $^{113m}$In was measured. Both ground-state and isomeric activities were observed in $^{112}$In and $^{114}$In and isomeric cross section ratios were determined. Statistical arguments were used in proposing spin-parity assignments for $^{112}$In and $^{114}$In levels. (J.W.R.)

**21336** DECAY OF $^{103}$Ru. Ruskov, T.; Tomov, T.; Lefterov, D.; Srents, A. (Inst. of Physics, Sofia). Compt. Rend. Acad. Bulg. Sci., 21: 1273-4(1968). (In Russian).

The gamma spectrum resulting from the decay of $^{103}$Ru was measured using a Ge(Li) detector. A decay scheme was constructed for $^{103}$Ru. (D.C.W.)

**21337** THE HIGH-ENERGY $\gamma$ RADIATION ACCOMPANYING THE DECAY OF $^{214}$Bi. Ythier, Christian; Maria, Henriette; Ardisson, Gerard (Faculte des Sciences, Nice). Compt. Rend., Ser. A and B, 267: 1109-12(Nov. 13, 1968). (In French).

A new study of the high-energy $\gamma$ radiation of $^{226}$Ra and its daughters, carried out with a pair spectrometer, does not confirm the existence of $\gamma$ rays of 2918 and 2962 keV, but has shown new $\gamma$ rays of 2087.1, 2110.3, 2260.4, 2601.8, 2631.9, and ~3265 keV. The assignment to $^{214}$Po of the $\gamma$ rays observed is discussed. (tr-auth)

**21338** THE PARAMETERS OF THE 0.099-eV NEUTRON RESONANCE IN $^{149}$Sm. Asami, Tetsuo; Okamoto, Koichi; Ideno, Kazumi; Ohno, Yoshihisa (Japan Atomic Energy Research Inst., Ibaraki). J. Phys. Soc. Jap., 26: 225-32(Feb. 1969).

Measurements of the 0.099-eV resonance in $^{149}$Sm were made with a crystal spectrometer and a neutron velocity selector in the energy range from 0.0006 to 1 eV. Samples highly enriched to 97.42% in $^{149}$Sm were used. The observed neutron transmissions were analyzed by a shape method using a Breit–Wigner single-level formula. The resonance parameters obtained from the analysis are: $E_0$ = 0.0989 ± 0.0008 eV; $\Gamma$ = 59.5 ± 0.8 MeV; and $\Gamma_n^0$ = 1.71 ± 0.03 MeV, assuming the statistical weight factor is 9/16. The 2200 m/sec value of the total cross section is 37,000 ± 1,600 barns. (auth)

**21339** LEVEL STRUCTURE OF $^{138}$Cs FROM THE SHORT-LIVED FISSION PRODUCT $^{138}$Xe. Nagahara, Teruaki; Tomura, Kenji; Miyah, Nobuyoshi; Kurihara, Hideaki; Mizuno, Yukiko (Rikkyo Univ., Yokosuka, Jap.). J. Phys. Soc. Jap., 26: 232-6 (Feb. 1969).

Gamma rays from the 15-min fission product $^{138}$Xe were studied with Ge(Li) detectors, Na(Tl) crystals, and coincidence equipment. Gamma rays of the following energies and relative intensities were observed: 153.2 (26), 242.8 (9.6), 258.2 (100), 396.5 (16), 401.7 (9.0), 434.6 (48), 1770 (39), 2002 (14), and 2013 keV (29). From the measurements of the singles gamma-ray spectrum and the gamma-gamma coincidence spectra, the proposed levels in $^{138}$Cs are at 15.4, 258.5, 411.4, 434.6 (or 450.0), 2028.4, and 2413.4 keV. (auth)

**21340** EXCITATION CURVE FOR THE REACTION $^{181}$Ta(n,p)$^{181}$Hf IN THE 13- TO 17.5-MeV ENERGY RANGE. Brzosko, J. S.; Gierlik, E.; Napiorkowska, M.; Soltan, A. Jr.; Wilhelmi, Z. (Univ. of Warsaw. Inst. of Nuclear Research, Warsaw). Acta Phys. Pol., 35: 413-15(Mar. 1969).

The activation method was applied in measurements of cross sections in the reactions $^{181}$Ta(n,p)$^{181}$Hf in the 13- to 17.5-MeV neutron energy range. Experimental results were compared with those predicted theoretically by the statistical model. This comparison shows that the process of compound-nucleus formation makes only a small contribution to the reaction in question. (auth)

**21341** EXCITATION CURVE FOR THE REACTION $^{181}$Ta(n,$\gamma$)$^{182}$Ta IN THE 0.03- TO 5.1-MeV NEUTRON ENERGY RANGE. Brzosko, J. S.; Gierlik, E.; Saganek, A.; Soltan, A. Jr.; Wilhelmi, Z. (Univ. of Warsaw. Inst. of Nuclear Research, Warsaw). Acta Phys. Pol., 35: 417-20(Mar. 1969).

The activation method was applied in measurements of the cross sections of the $^{181}$Ta(n,$\gamma$)$^{182}$Ta reaction in the neutron energy range from 0.03 to 5.1 MeV. The agreement of the experimental results with those predicted theoretically by the statistical model was good on the assumption that the formula for the $\gamma$-ray emission

probability depends on the γ-ray absorption cross-section. It was necessary to assume that a giant E1 resonance and a pigmy resonance exist. The agreement was poor when the probability of γ-ray emission was assumed to be proportional to $E_\gamma^3$ ($E_\gamma$ being the energy of γ quanta). (auth)

**21342** β−γ ANGULAR CORRELATIONS USING SOURCES OF THORIUM ACTIVE DEPOSIT. Scott, R. D.; Kyles, J. (Univ. of Edinburgh). J. Phys. A (London), 2: 220-6 (Mar. 1969).

β−γ angular correlations were studied for the following cascades occurring in the decay chain of the thorium active deposit: 350 keV β−239 keV γ in the ThB → ThC decay; 1.52 MeV β−729 keV γ in the ThC → ThC′ decay; and 1.80 MeV β−583 keV γ in the ThC″ → ThD decay. In all three cases a null result was obtained. The β decays in question are of the first-forbidden type according to the accepted decay schemes and might, therefore, have been expected to show some anisotropy in the β−γ angular correlation. The β transitions in the first and third cascades have rather low (<6) lg ft values, more in keeping with an allowed assignment, but it is concluded that the lack of a measurable anisotropy is not sufficient evidence to warrant the adoption of a possible alternative decay scheme which would make all three decays of allowed type. (auth) (UK)

**21343** SMALL ANGLE ELASTIC SCATTERING OF 14-MeV NEUTRONS BY $^{238}$U. Adam, A.; Deak, F.; Hrasko, P.; Jeki, L.; Kiss, A.; Koevesy, Zs.; Palla, G. (Central Research Inst. for Physics, Budapest). Acta Phys. Acad. Sci. Hung., 25: 261-73 (1968).

The theories proposed by various authors for the explanation of the apparently anomalous small-angle elastic scattering of fast neutrons by $^{238}$U nuclei are reviewed. The problem is then considered by questioning the validity of the model and the assumptions which give rise to the anomalous discrepancy between the predictions and the experimental data. The measurement of the angular distribution of 14.7-MeV neutrons scattered elastically by $^{238}$U is reported. In the evaluation of the experimental data the inelastic contribution is taken into account as a consequence of bad energy resolution. The analysis of the scattering data in terms of the optical model does not show the occurrence of any anomaly. (auth)

**21344** IMPLICATIONS OF RECENT FISSION-AVERAGED CROSS-SECTION MEASUREMENTS. McElroy, W. N. (Battelle Memorial Inst., Richland, Wash.). Nucl. Sci. Eng., 36: 109-13(Apr. 1969).

The discrepancies found in several studies of the thermal neutron fission spectrum of $^{235}$U are discussed. The inconsistency between differential and integral measurements and between calculated and measured values are noted. The best overall consistency in fission-averaged cross sections is obtained with the Grundl and SAND-II representations. (J.N.R.)

**21345** GAMMA–GAMMA ANGULAR CORRELATION STUDIES IN $^{132}$Xe. Fruscello, T. W.; Cothern, C. R. (Univ. of Dayton, Ohio). Nuovo Cim., 60B: 193-8(Mar. 11, 1969).

Directional γ−γ correlations were done for the (1.14−0.773) MeV and (0.520−0.773) MeV cascades in $^{132}$Xe. The mixing ratio for the 1.14-MeV transition was determined and the 2.58-MeV level was assigned spin 3⁻, consistent with the belief that the level was an octupole vibration state. This resulted in a discussion of the systematics of the lowest 3⁻ level of neighboring even nuclei. (auth)

**21346** EXCITED STATES OF $^{119}$Sb. Gasior, M.; Niewodniczanski, H.; Potempa, A. W.; Sieniawski, J. (Inst. of Nuclear Physics, Krakow). Acta Phys. Pol., 35: 453-8(Mar. 1969).

A magnetic beta spectrometer of high transmission was used to measure the energies and intensities of the internal conversion electron lines following the decay of $^{119m}$Te. The existence of the 116.4 and 871.2-keV transitions was confirmed. Several lines of very weak intensities, whose decay times are near the value of the $^{119m}$Te lifetime, were observed for the first time. The conversion coefficients were evaluated for most of the observed transitions. The following spin values for the excited states of $^{119}$Sb are suggested: 0 keV, $\frac{1}{2}^-$; 270.3 keV, $\frac{1}{2}^+$; 1048.1 keV, $\frac{1}{2}^+$; 1212.6 keV, $\frac{3}{2}^+$; 1249 keV, $\frac{5}{2}^+$; 1365.8 keV, $\frac{11}{2}^-$; 1407 keV, $\frac{5}{2}$, $\frac{11}{2}^+$; 2129 keV, $\frac{5}{2}^-$; 2226 keV, $\frac{5}{2}$, $\frac{11}{2}^+$; and 2278 keV, $\frac{5}{2}$, $\frac{13}{2}^-$. (auth)

**21347** LOW-ENERGY γ RADIATION OF $^{228}$Th AND ITS DERIVATIVES AND THE MULTIPOLAR CHARACTER OF THE $^{212}$Po TRANSITIONS. Dalmasso, Josette; Marsol, Claire (Laboratoire de Chimie Physique Atomique et Structurale, Nice). Compt. Rend., Ser. A, B, 267: 1366-9(Dec. 16, 1968). (In French).

The energy and relative intensity of the low-energy γ radiation observed in the decay of $^{228}$Th and its derivatives were measured. The assignment of these radiations is discussed. (J.S.R.)

**21348** HIGH-ENERGY γ RADIATION ACCOMPANYING DECAY OF $^{212}$Bi. Ythier, Christian; Forest, Hugues; Ardisson, Gerard; Maria, Henriette (Laboratoire de Chimie Physique Atomique et Structurale, Nice). Compt. Rend., Ser. A, B, 267: 1362-5(Dec. 16, 1968). (In French).

A study was made of the γ radiation of $^{212}$Po in order to make more precise the spin and parity of the excited levels and to determine the origin of the long-range α particles that it emits. The γ spectrum obtained had two previously unreported radiations at 1679.5 and 1806.0 keV. The relative intensities of the γ rays were determined and were compared with the values obtained by other investigators. The decay scheme is discussed in detail. (tr-auth)

**21349** STUDY OF THE DECAY SCHEME OF $^{124}$I. Lagrange, Jean-Marie (Institut de Physique Nucleaire, Orsay, France). Compt. Rend., Ser. A, B, 267: 1354-7(Dec. 16, 1968). (In French).

The study of the γ radiation coming from the decay of $^{124}$I leads to a proposal for the decay scheme of this isotope. The nature of the excited levels of $^{124}$Te was also examined. (tr-auth)

**21350** OBSERVATION OF NEW HIGH-ENERGY GAMMAS FROM $^{132}$I. Ardisson, Gerard; Dalmasso, Josette; Ythier, Christian (Faculte des Sciences, Nice). Compt. Rend., Ser. A, B, 268: 97-9(Jan. 6, 1969). (In French).

The gamma radiation from $^{132}$I formed in $^{132}$Te was studied at high energy using a pair spectrometer with a central n-i-p Ge(Li) detector. The improvement in the resolution permitted the observation of twelve new gammas. (tr-auth)

**21351** NUCLEAR g-FACTOR OF THE 2⁺″ GAMMA VIBRATIONAL STATE IN $^{160}$Dy. Simon, R.; Arens, I.; Raghavan, R. S.; Koerner, H. J. (Technische Hochschule, Munich). Phys. Lett., 28B: 590-1(Mar. 3, 1969).

Perturbed angular correlations were measured for $^{160}$Dy in Tb metal at 77°K to derive the Larmor precession $\omega_L\tau = (14.3 \pm 1.3) \times 10^{-3}$ rad and the g-factor $g = +0.18 \pm 0.06$ for the 966-keV state in $^{160}$Dy. (auth)

**21352** PROTON DECAY OF THE ISOBARIC ANALOG OF THE GROUND STATE OF $^{209}$Pb POPULATED BY THE (p,n) REACTION. Igo, G. J. (Univ. of California, Los Angeles); Whitten, C. A. Jr.; Perrenoud, Jean-Luc; Verba, J. W.; Woods, T. J.; Young, J. C.; Welch, L. Phys. Rev. Lett., 22: 724-7 (Apr. 7, 1969).

The relative widths for the proton (p̄) decay of the isobaric analog of the $^{209}$Pb ground state were remeasured with significantly improved accuracy using the charge-exchange reaction $^{208}$Pb(p,n) rather than $^{207}$Pb(p,p) and (p,p′) excitation functions to populate the isobaric analog level. For the first time the sequential process (p,np̄) was observed both with a heavy (A ~ 200) target nucleus and also with a target nucleus which is even-even rather than even-odd. The total cross section for the isobaric-analog-state reaction $^{208}$Pb(p,n)$^{208}$Bi was also measured for the range of proton bombarding energies between 25.2 and 47.3 MeV. (auth)

**21353** SPIN DETERMINATION OF ISOBARIC ANALOGUE RESONANCES IN $^{209}$Bi AND $^{207}$Bi BY PROTON POLARIZATION MEASUREMENTS. Fiarman, S.; Marquardt, N. (Max-Planck-Institut fuer Kernphysik, Heidelberg). Z. Phys., 221: 494-7 (1969).

The polarization of elastically scattered protons from $^{208}$Pb and $^{206}$Pb was measured. The spins of some isobaric analogue resonances in $^{209}$Bi and $^{207}$Bi in the energy region from 16.2 to 17.8 MeV were determined. (auth)

**21354** GAMMA-RAY SPECTRUM EMITTED IN THE DECAY OF $^{153}$Sm to $^{153}$Eu. Patin, Yves (CNRS, Orsay, France). Compt. Rend., Ser. A, B, 268: 574-7(Feb. 17, 1969). (In French).

The gamma spectrum from the decay $^{153}$Sm → $^{153}$Eu was observed using a Ge(Li) detector with a field effect transistor preamplifier. The resolution obtained permitted the observation of new lines and improvement of the accuracy of the energies. (tr-auth)

**21355** STRUCTURE AND REACTION CALCULATIONS IN THE RPA. Dietrich, Klaus; Dover, Carl B. (Univ., Heidelberg). Z. Phys., 221: 340-5(1969).

The cross sections for the reaction $^{207}$Pb(n,n′)$^{207}$Pb* and the influence of continuum coupling on states in $^{208}$Pb are discussed within the framework of the RPA. (auth)

**21356** SPIN DETERMINATION OF ISOBARIC ANALOG STATES IN N = 85 AND 87 NUCLEI BY ELASTIC SCATTERING POLARIZED PROTONS. Graw, G.; Clausnitzer, G.; Fleischmann, R.; Wienhard, K. (Univ. Erlangen, Ger.). Phys. Lett., 28B: 583-4(Mar. 3, 1969).

The spin of the lowest observed isobaric analogue resonance, corresponding to the lowest state observed in (d,p), was determined as $J = 1/2$ for $^{142}$Ce, $^{144}$Nd, and $^{146}$Nd targets whereas the ground-state isobaric analogue resonances should have the spins $3/2$, $1/2$, and $5/2$, respectively. (auth)

**21357** THEORETICAL INTERPRETATION OF ISOMERIC CROSS SECTION RATIOS FOR TWO (d,2n) REACTIONS. Caracoche, M. C. (La Plata National Univ.). Nucl. Phys., A127: 458-64(1969).

Isomeric cross section ratios as functions of incident energy between 10 and 20 MeV were theoretically calculated for $^{133m}$Ba, $^{132}$Ba, and $^{121m}$Te, $^{121}$Te formed in (d,2n) reactions. Assuming the compound nucleus reaction mechanism, three different level density models were used in the calculation; the independent-particle Fermi-gas model, the shifted Fermi-gas model and the superconductor model. The best fits to experimental data were obtained from the superconductor model, a rather satisfactory fact considering that in both reactions studied, the intermediate and final nuclei are even- and odd-mass nuclei, respectively. (auth)

**21358** NEUTRON STRENGTH FUNCTIONS FROM MODEL EQUILIBRIUM DEFORMATIONS FOR TRANSURANIC NUCLEI. Gigas, G. (Atomics International, Canoga Park, Calif.). Nucl. Phys., A127: 465-73(1969).

Average neutron s-, p- and d-wave strength functions for 58 heavy, doubly even rotor nuclei from $^{220}$Em to $^{262}$(104) were calculated with a strong coupling deformed nucleus model using single-particle potential equilibrium deformations derived from projected wave functions with and without a charge term, BCS functions, and an independent-particle-model approximation. The optical-model potentials employed were corrected for both the symmetry number and the Coulomb parameter. In comparison to existing strength function data, it is found that although the differences between the models are often less than the uncertainties assigned to the measurements, for s-waves, the general agreement is better for those model variants which include a Coulomb term in the potential. (auth)

**21359** PARTICLE-VIBRATION COUPLING IN $^{209}$Bi. Broglia, R. (Univ., Copenhagen); Damgard, J.; Molinari, A. Nucl. Phys., A127: 429-37(1969).

The coupling between single-particle states and the collective octupole state in $^{208}$Pb is calculated with the Hamada-Johnston potential (Kuo and Brown G-matrix). (auth)

**21360** LIFETIME MEASUREMENTS FOLLOWING COULOMB EXCITATION. Avida, R.; Dar, Y.; Gilad, P.; Goldberg, M. B.; Speidel, K. H.; Wolfson, Y. (Weizmann Inst. of Science, Rehovot, Israel). Nucl. Phys., A127: 412-16(1969).

The lifetimes of $2^+$ states in $^{158}$Gd, $^{160}$Gd, $^{164}$Dy, $^{170}$Er were measured by charged particle gamma delayed coincidence following Coulomb excitation. The values obtained (in nsec) are $3.74 \pm 0.17$, $3.88 \pm 0.08$, $3.46 \pm 0.11$, and $2.81 \pm 0.11$, respectively. (auth)

**21361** NUCLEAR RESONANCE FLUORESCENCE FROM THE 375-keV LEVEL IN $^{127}$I. Langhoff, H.; Gfoeller, D. Univ., Goettingen, Ger.). Nucl. Phys., A127: 379-84(1969).

Using gaseous sources of $^{127}$Xe nuclear resonance fluorescence was observed from the 375-keV level in $^{127}$I. The lifetime of the level was determined to be $\tau = 22 \pm 4$ psec. The dependence of the resonant scattering on the source temperature yielded the total transition energy of $^{127}$Xe to be $Q_{EC} = 684 \pm 22$ keV. The cross section for resonant scattering was also influenced by the application of an electrical field to the source. (auth)

**21362** THE DECAY OF $^{153}$Sm. Ungrin, J.; Johns, M. W. (McMaster Univ., Hamilton, Ont.). Nucl. Phys., A127: 353-67 (1969).

The beta decay of $^{153}$Sm was studied using Ge(Li) and NaI detectors singly and in a two-parameter coincidence experiment. The energies and intensities of 49 gamma rays were determined. The results of singles and coincidence experiments have led to the identification of levels at 0.0 ($5/2^+$[413]), 83.4($7/2$, $5/2^+$[413]), 97.5 ($5/2^-$[532]), 103.2 ($3/2^+$[411]), 151.6 ($7/2$, $3/2^-$[532]), 172.9 ($5/2$, $3/2^+$[411]), 269.9 ($7/2$, $3/2^+$[411]), 634.6, 636.5 ($5/2^+$[422]), 657.6, 681.9 ($5/2$, $3/2^+$[422]), 694.2, 701.4, 706.6, 718.6, and 760.3 keV in $^{153}$Eu. The branching ratios of the gamma rays from the 636.5- and 681.9-keV states and the absence of these levels in the deuteron spectra of the $^{152}$Sm($^3$He,d)$^{153}$Eu reaction lead to a rejection of the previously proposed identification of the 636.5-keV state with the Nilsson $1/2^+$[411] state. A $3/2^+$[422] "hole" state interpretation is proposed. (auth)

**21363** BETA AND GAMMA VIBRATIONAL BANDS IN $^{152}$Sm AND $^{154}$Gd. Varnell, L.; Bowman, J. D.; Trischuk, J. (California Inst. of Tech., Pasadena). Contract AT(04-3)-63. Nucl. Phys., A127: 270-88(1969).

Relative intensities of gamma transitions in $^{153}$Sm, $^{152}$Gd, and $^{154}$Gd were measured using a Ge(Li) detector. Several new gamma transitions were observed. Angular correlation experiments were performed to determine the multipole mixing ratios of transitions from the gamma vibrational band to the ground state band in $^{154}$Gd. It is found that neither the beta nor the gamma band transition strengths in $^{152}$Sm and $^{154}$Gd can be accounted for by a single parameter band-mixing theory, nor can agreement be found by considering mixing between the beta and the gamma band. Transition rates from the negative-parity levels also disagree with predictions of the strong coupling model including first-order corrections. (auth)

**21364** SEARCH FOR STABLE ELEMENTS HEAVIER THAN URANIUM. Phys. Today, 22: No. 2, 63-7(Feb. 1969).

Some recent predictions concerning transactinide elements, particularly those with Z = 110 and 114, are summarized; and experimental attempts to observe these elements are outlined. (D.C.W.)

**21365** NUCLEAR SYSTEMATICS AND THE PREDICTION OF HEAVY ELEMENT STABILITY. Viola, V. E. Jr. (Univ. of Maryland, College Park). pp 135-52 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

Predictions of nuclear masses and stability for Ar greater than 140 nuclei, made from alpha and beta decay energy systematics, are discussed. (J.W.R.)

**21366** NEW MASSES FOR NUCLIDES WITH A > 212. Wapstra, A. H. (Instituut voor Kernphysisch Onderzoek, Amsterdam); Kurzeck, C.; Anisimoff, A. pp 153-93 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

In connection with the preparation of Nuclear Data Sheets for A > 212, a new list of atomic masses of nuclides and derived reaction and binding energies was calculated from experimental data. A recently discovered discrepancy in the data was removed in a satisfactory way. (auth)

**21367** COMPILATION OF EXPERIMENTAL $E_\alpha$ VALUES IN THE REGION ABOVE Z = 81 AND BELOW N = 128. Valli, Kalevi (Univ. of California, Berkeley). pp 296-326 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

Data on $\alpha$ energies, $\alpha$-decay energies, $\alpha$ branches, and half-lives are given for isotopes of actinium, astatine, bismuth, francium, lead, polonium, radium, radon, and thorium which have less than 128 neutrons are tabulated. 59 references. (J.W.R.)

**21368** ATOMIC MASSES OF NUCLIDES FAR FROM BETA STABILITY. MacFarlane, R. D. (McMaster Univ., Hamilton, Ont.); Cerny, Joseph. pp 327-44 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

The study of the nuclear mass surface in regions far from beta stability is discussed. Methods for producing nuclei in the highly neutron rich and deficient regions are described as well as methods for the properties of these nuclei. Some information gained from such studies is discussed. (J.W.R.)

**21369** PARTICLE CONFIGURATIONS IN $^{207}$Pb. Darcey, W. (Nuclear Physics Lab., Oxford). pp 639-56 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

The results of work on the reaction $^{206}$Pb(d,p)$^{207}$Pb indicate that, although the bulk of the single particle strength is concentrated in a small number of states in $^{207}$Pb, there is considerable fragmentation of the basic (2h-1p) states, and in particular the d $5/2$ and d $3/2$ states. New assignments are proposed for the levels previously considered to be the i $11/2$ and j $15/2$ (2h-1p) states and alternative locations are suggested for these states. It is evident that the simple (2h-1p) description of $^{207}$Pb is inadequate and that further work will be needed to explain the states observed in spectrum of $^{207}$Pb. (auth)

**21370** NUCLEAR Q-VALUE MEASUREMENTS ON A SERIES OF ACTINIDE NUCLEI. Erskine, J. R.; Friedman, A. M.; Braid, T. H.; Chasman, R. R. (Argonne National Lab., Ill.). pp 622-38 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

Stripping and pick-up reactions on various even-even isotopes in the actinide region were studied. One of the results of this work was the determination of Q-values of the (d,p) and (d,t) reactions on these isotopes. The Q-values obtained are in many cases the first direct measurements of the mass differences between these isotopes. The targets studied were $^{230}$Th, $^{232}$Th, $^{234}$U, $^{236}$U, $^{238}$U, $^{240}$Pu, $^{242}$Pu, $^{244}$Cm, $^{246}$Cm, and $^{248}$Cm. (auth)

**21371** ATOMIC MASS DETERMINATIONS AT McMASTER UNIVERSITY AND THE UNIVERSITY OF MANITOBA. PART I. NUCLEAR BINDING ENERGIES IN THE REGION $82 \leq N \leq 126$. McLatchie, W.; Macdougall, J. D.; Whineray, S.; Duckworth, H. E.; Barber, R. C.; Hogg, B. G.; Van Rookhuyzen, P. (McMaster Univ., Hamilton, Ont.). pp 702-16 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

Mass differences were determined for nuclei in the region $82 \leq N \leq 126$ using a mass spectrometer. From these measurements double neutron separation energies were determined. The data were compared with other precise measurements. (J.W.R.)

**21372** ISOTOPE MASSES AND BINDING ENERGIES OF NUCLEI FROM CESIUM TO EUROPIUM. Demirkhanov, R. A.; Dorokhov, V. V.; Dzkuya, M. I. (Physical-Technical Inst., Sukhumi, USSR). pp 864-901 of Proceedings of the Third International Conference on Atomic Masses, University of Manitoba, Winnipeg, Canada, August 28–September 1, 1967. Barber, R. C. (ed.). Winnipeg, Can., University of Manitoba Press, 1967.

See CONF-670818.

Stable isotope masses of Cs, Ba, La, Ce, Pr, Nd, Sm, and Eu, were measured by means of mass-spectroscopy techniques. One hundred and thirty-six various doublets were measured and the masses of 31 stable isotopes were calculated in the indicated region. Mass measurements on all of the elements were carried out with the examination of "internal" agreement. Closed cycle techniques are used for this purpose. The accuracy of nuclear mass measurements in a number of cases is increased 3 to 10 times relative to data available in the literature. The measurement relative error is $\Delta M/M = 2$ to $5 \times 10^{-7}$. Using the measured nuclear masses as a basis, masses and binding energies of nearly 180 radioactive nuclei over the investigated range of masses were calculated by means of nuclear reaction Q-values, $\alpha$- and $\beta$-decays and nuclear parameter variation systematics. Quantitative variations of the last neutron and proton binding energies, neutron and proton pairs, pairing energies, etc., were calculated near the "magic" number N = 82. The possibility of nuclei deformation boundary determination has been indicated by means of binding energies of the last neutrons and pairing energies. (auth)

**21373** ENERGY LEVELS OF $^{243}$Am. Friedman, A. M.; Ahmad, I.; Milsted, J.; Engelkemeir, D. W. (Argonne National Lab., Ill.). Nucl. Phys., A127: 33-46(1969).

The energy levels of $^{243}$Am were investigated by studying the $\gamma$ rays and conversion electrons of $^{243}$Pu and $\alpha$ groups of $^{247}$Bk by high-resolution semiconductor detectors. Some new $\gamma$ rays were identified and the multipolarities of the 381.7 and 356.4 keV transitions were measured to be M1. The half-life of the 84.0 keV level was measured by a delayed $\beta-\gamma$ ray coincidence technique and found to be 2.34 ± 0.07 ns. Nine $\alpha$ groups belonging to $^{247}$Bk decay were identified and the favored transition was found to populate a level at 267 keV above the ground state. The Nilsson-state assignments to the $^{243}$Am levels agree with the previous assignments. Coriolis interaction calculations were performed to explain the contraction of the $\frac{5}{2}^+(642\uparrow)$ band and the branching ratios of the intensities of the $\gamma$ rays deexciting the $\frac{7}{2}^+(633\uparrow)$ band to the rotational members of the $\frac{5}{2}^+(642\uparrow)$ band. The calculated values of the level spacings the $\gamma$-ray intensity ratios and $\alpha$ intensity ratios were found to be in good agreement with the respective observed quantities. (auth)

## Nuclear Theory

*Refer also to abstracts 21026, 21052, 21127, 21153, 21237, 21241, 21267, 21268, 21286, 21290, 21321, 21323, 21328, 21355, 21358, and 21359.*

**21374** (ZFK-130, pp 1-10) INTERMEDIATE STRUCTURE OF CROSS SECTIONS. Lovas, I. (Joint Inst. for Nuclear Research, Dubna (USSR)).

The problem of intermediate structure in nuclear reaction cross sections is reviewed, and it is shown how intermediate structure may be used as a source of information on nuclear structure. (J.W.R.)

**21375** (ZFK-130, pp 11-19) ISOSPIN-DEPENDENCE OF THE NUCLEAR OPTICAL POTENTIAL. Mueller, Kh. (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)).

The importance and the role of the isospin-dependent optical potential in model calculations are traced from first-principles. (J.W.R.)

**21376** (ZFK-130, pp 58-69) NUCLEON CORRELATIONS IN NUCLEAR p-SHELL. Smirnov, Yu. F. (Moscow State Univ. (USSR). Inst. for Nuclear Physics). (In Russian).

Results on problems of nucleon correlations in light elements are reported. A translation-invariant shell model which uses a translation-invariant potential of a harmonic oscillator whose center corresponds with the center of inertia of the nucleus was used in analyzing the effects of nucleon correlations. In such a model the variable center of inertia generally does not enter into the wavefunction of the nucleus. Fractional parentage coefficients were introduced, and a method of factoring these coefficients into orbital and spin-isospin parts was obtained. From a knowledge of the fractional parentage coefficients it was possible to construct in explicit form the wave functions of the nuclear states and to calculate the matrix elements of the operators. It thus became possible to calculate reduced widths or effective number of associations, and to use these for analyzing various direct reactions with the participation of complex particles at low and high energies. Rules of selection from Jung's scheme were found by means of Littlewood's theorem. The following reactions were analyzed: $^9$Be → 2$\alpha$ + n(1.5 MeV), $^7$Li → $\alpha$ + t(4 MeV), elastic and inelastic quadrupole scattering of electrons in $^6$Li, momentum distribution of recoil alpha particles during absorption of $\pi^-$-mesons by $^6$Li, and angular correlation of the two final products in the $^6$Li(p,2p)$^5$He reaction. Nuclear reactions with nucleon correlations are discussed for ($^3$He,p) and ($\alpha$,d) type of reactions. (TTT)

**21377** (ZFK-130, pp 70-82) RECENT HARTREE–FOCK CALCULATIONS AND RELATED PROBLEMS. Giraud, B. (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires).

The Hartree–Fock method for nuclear structural calculations is described, and some problems which have been solved by the method are reviewed. (J.W.R.)

**21378** (ZFK-130, pp 179-81) PROJECTED DEFORMED STATES AND ANHARMONIC VIBRATION IN SPHERICAL NUCLEI. Broglia, R. A.; Soerensen, B. (Niels Bohr Institutet, Copenhagen (Denmark)); Udagawa, T. (Nordisk Institut for Teoretisk Atomfysik, Copenhagen (Denmark)).

Recent observations of the large static quadrupole moment of the first excited $2^+$ state of even spherical nuclei were considered as evidence for the anharmonicity of vibrational modes of these nuclei. Calculations were performed assuming a small axial-symmetric quadrupole deformation and using projected deformed wave functions. The results show that the large observed moments may be explained as an effect of the axial-symmetric deformation. (J.W.R.)

**21379** (ZFK-130, pp 182-3) GENERALIZED BCS METHOD FOR NEUTRON–PROTON PAIRING CORRELATIONS. Kissener, H. R.; Muenchow, L. (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)).

A method for treating the charge-independent pairing interaction by means of the general linear Bogolyubov transformation combined with corrections for nucleon number and isospin fluctuations was extended to the case of several nondegenerate single-particle levels. (J.W.R.)

**21380** (ZFK-130, pp 184-5) BEHAVIOUR OF THE PAIRING SOLUTION IN THE VICINITY OF THE CRITICAL POINT. Jaeger H.-U.; Kissener, H.-R.; Muenchow, L. (Zentralinstitut fuer Kernforschung, Rossendorf bei Dresden (East Germany)).

The behavior of the pairing solution near the critical point for the pairing constant was investigated using a pure pairing model for a closed shell nucleus. In order to use the BCS formalism near the critical point, BCS states were projected to states with fixed isospin and particle number. (J.W.R.)

**21381** (ZFK-130, pp 239-45) REMARKS ON SUMMATION AND INTEGRATION OF SPHERICAL HARMONICS USING THE

GRAPHICAL METHOD. Lehmann, D. (Leipzig Univ. (East Germany). Physikalisches Institut).

It is shown that the graphical rules for Clebsch-Gordon coefficients are related to the graphical representation of spherical harmonics, and that the same rules are valid for both representations. (J.W.R.)

**21382** EXCHANGE DIAGRAMS IN THE THEORY OF NUCLEAR MATTER. Lawson, P. A.; Sampanthar, S. (Univ. of Salford, Eng.). J. Phys., A (London), 2: 246-8(Mar. 1969).

It is shown that the result of including all the exchange diagrams in the expression for the binding energy due to four-body correlations in nuclear matter is to reduce the binding energy due to the direct interaction by a factor of about 3/32. (auth) (UK)

**21383** ATOMIC AND NUCLEAR PHYSICS: AN INTRODUCTION IN S.I. UNITS. SECOND EDITION. Littlefield, T. A.; Thorley, N. London, Van Nostrand, 1968. 484p. 55s.

Atomic and nuclear physics are treated in detail using the International System of units. (J.W.R.)

**21384** NUCLEAR REACTIONS INDUCED BY HIGH ENERGY $^{12}C$. Okabe, Tetuji (Tamagawa Univ., Japan). Mem. Fac. Eng., Tamagawa Univ., No. 2, 31-40(June 1968). (In Japanese).

The total cross sections for $^{12}C$ production from high-energy $^{12}C$-induced reactions on heavy target elements are calculated by means of stripping and electrodisintegration processes. For target elements with A = 100, Z = 40, the stripping cross section is 64 mb and the electrodisintegration cross section is 9 mb. These values are compared with the results in deuteron-induced processes and are shown to be about 0.25 in comparison with the corresponding values of deuteron cases. (NSA of Japan)

**21385** MASS FORMULA IN SHELL MODEL. Lee, Kiuck (Marquette Univ., Milwaukee); Kim, Chung-hum. J. Korean Phys. Soc., 1: 97-102(Oct. 1968).

A correction term for the nuclear binding energy in the shell model is derived. The resulting expression fits well, with one adjustable parameter for each model Hamiltonian, to the experimental binding energies for the entire range of nuclear masses. The relation with the usual velocity-dependent potential approximation is discussed, and a comparison with the results from Brueckner's theory is given. (auth)

**21386** THREE-NUCLEON TRANSFER REACTIONS. Ho-Kim, Q. (Laval Univ., Quebec). Nuovo Cim., 60B: 71-85 (Mar. 11, 1969).

The triple-nucleon transfer reaction was studied with particular reference to the $(\alpha,p)$ reaction. In addition to the familiar parentage selectivity, there exists a new type of selectivity based on the coherent contributions from several different particle configurations. The transition amplitude may be factorized into a structure part, giving spectroscopic information, and a kinematic part, depending on the mechanism involved. This factor, represented by an integral, was calculated in the plane-wave and distorted-wave approximations. Effects of nuclear structure and force range were also examined. And finally several specific nuclear reactions were considered. (auth)

**21387** $SU_3$ SYMMETRY AND EFFECTIVE INTERACTIONS IN THE s-d SHELL. Kulkarni, D. R. (Physical Research Lab., Ahmedabad, India); Pandya, S. P. Nuovo Cim., 60B: 199-209 (Mar. 11, 1969).

The effective interaction in the s-d shell can be characterized in terms of diagonal radial matrix elements $I_{nls}$ in relative states of orbital angular momentum l of two nucleons. The symmetry properties of radial matrix elements in l = 0 states were investigated. The parameters $I_{0s}$ and $I_{2s}$ were shown to give exact $SU_3$ symmetry of the eigenfunctions. The $SU_3$-symmetry-breaking property of $I_{1s}$ was explicitly demonstrated, but it was also found that in realistic calculations such an effect is somewhat suppressed by the single-particle spin-orbit force. It is also shown that whereas the T = 1 eigenfunctions (for J = 0, 2, 4 for two nucleons) can be very well generated from a suitable deformed intrinsic state, the T = 0 eigenfunctions (J = 1, 2, 3) generated from deformed states have poor overlaps with shell-model eigenfunctions in the absence of spin-orbit splitting of single-particle orbits. Inclusion of single-particle spin-orbit force improves very strikingly the overlaps between the generated and the shell-model T = 0 states. (auth)

**21388** TABLES OF COEFFICIENTS FOR THE ANALYSIS OF TRIPLE ANGULAR CORRELATIONS OF GAMMA-RAYS FROM ALIGNED NUCLEI. Kaye, G.; Read, E. J. C.; Willmott, J. C. Oxford, Pergamon Press Ltd., 1968. 230p. $12.00.

Tables of Clebsch-Gordan coefficients and angular correlation coefficients for the analysis of triple angular correlation measurements are presented. (D.C.W.)

**21389** MODEL OF DEFORMED NUCLEI FOR FISSION WITH EMISSION OF A LIGHT PARTICLE. Doan, Thu Phong; Carles, Claude; Asghar, Muhammad; Chastel, Raymond (Laboratoire de Physique Nucleaire, Bordeaux). Compt. Rend., Ser. A, B, 267: 1350-3(Dec. 16, 1968). (In French).

By consideration of the model of two surface-charged revolution ellipsoids, there was agreement with the experimental results of tripartition. The model proposed makes it possible to calculate some basic parameters of nuclear physics. (tr-auth)

**21390** GROUP-THEORETIC APPROACH TO THE NUCLEAR-SHELL-MODEL M-SCHEME. Agassi, D. (CEN de Saclay, Gif-sur-Yvette, France). Nuovo Cim., 60B: 1-7(Mar. 11, 1969).

The M-scheme of nuclear shell-model calculations (basis wave functions have definite $J_z$ but not J) is established using group-theoretic considerations. The prescription obtained for constructing the energy matrix is especially suited for machine programming. (auth)

**21391** EXACTLY SOLUBLE MODEL FOR RESONANCE SCATTERING. Lovas, I.; Revai, J. (Joint Inst. for Nuclear Research, Dubna, USSR). Acta Phys. Acad. Sci. Hung., 25: 307-20(1968).

A model system is constructed consisting of a single particle potential and two interacting particles. The potential has two bound states so that four configurations exist for the two-particle system. One of these lies in the continuum giving rise to a resonance of the compound type. Both the potential and the two-particle interaction are of non-local and separable types. The exact transition amplitudes are obtained by means of Faddeev's method. The model is designed for checking the microscopic nuclear reaction theories. (auth)

**21392** DIFFRACTION MODEL APPLIED TO POLARIZATION EFFECTS IN STRIPPING REACTIONS. Verhaar, B. J. (Technische Hogeschool, Eindhoven, Netherlands). Phys. Rev. Lett., 22: 609-12(Mar. 24, 1969).

A generalized ring-locus model, previously introduced to explain the behavior of the de-excitation $\gamma$ pattern in inelastic $\alpha$-particle scattering, is applied to polarization effects in (d,p) reactions. The vector-polarization analyzing power of this reaction is shown to be almost independent of the angular width of the ring locus, but strongly dependent on the displacement of the ring locus relative to a plane through the center of the target nucleus. (auth)

**21393** EXCITATIONS OF SENIORITY 0, 2, AND 4 IN QUASI-PARTICLE THEORIES OF EVEN-EVEN SO-CALLED VIBRATIONAL NUCLEI. Sawicki, J. (International Atomic Energy Agency, Trieste, Italy. Univ., Trieste, Italy). Nuovo Cim., Suppl., 6: 696-725(1968).

Quasiparticle approaches to the description of low-lying states in even-even vibrational nuclei are outlined. The results obtained for even- and odd-parity states of even Sn isotopes using the quasiparticle second Tamm-Dancoff (QSTD) approximation are discussed in detail, as are calculations for Sn(t,p) and Sn(p,t) reactions in both the QSTD and the quasiparticle Tamm-Dancoff approximations. Preliminary results obtained for the $2^+$ states of $^{114}Cd$ using the QSTD approximation are also included. (D.C.W.)

**21394** PHOTOEFFECT AT HIGH ENERGIES. Malvano, R. (Univ., Genoa. Istituto Nazionale di Fisica Nucleare, Genoa). Nuovo Cim., Suppl., 6: 650-63(1968). (In Italian).

The most salient points of the various theoretical approaches to the photoeffect at high energy are described. The quasi-deuteron model and the Wilson model are examined. The developments and improvements introduced by Gottfried are then discussed. The independent-pair model is also considered. A brief survey is made of the most significant experimental data. Some possible future experimental studies are indicated. (tr-auth)

**21395** MEASUREMENT OF THE LIFETIME OF NUCLEAR STATES USING THE DOPPLER SHIFT METHOD. Bizzeti, P. G. (Univ., Florence). Nuovo Cim., Suppl., 6: 664-88(1968). (In Italian).

The various measurement techniques based on the Doppler effect are described. The limitations of the method and means of overcoming these limitations are discussed. The physical significance that this method can have for the measurement of half-lives is considered and illustrated. (tr-auth)

**21396** ANALYSIS OF BINDING ENERGIES OF LIGHT NUCLEI IN A SIMPLE SYMMETRIC SCHEME WITH THE COUPLING INTERACTIONS OF STATES WITH J = 0 AND T = 1, AND IN STATES WITH T = 0 AND J = ODD NUMBERS. Camiz, P. (Univ., Rome. Istituto Nazionale di Fisica Nucleare, Rome). Nuovo Cim., Suppl., 6: 689-95(1968). (In Italian).

The possibility of applying group theory to the study of light nuclei depends on the manner in which the contribution of isopairing can be evaluated. The details of the evaluation are given. Results

obtained in the study of the shells from $1p_{\frac{1}{2}}$ to $1f_{\frac{5}{2}}$ of the nuclei from $^{4}$He to $^{66}$Ge are presented in a general manner. (J.S.R.)

**21397** SEPARATION OF VARIABLES AND COUPLING BETWEEN ROTATIONAL AND INTRINSIC MOTION IN DEFORMED NUCLEI. Krutov, V. A. (Leningrad State Univ.). Ann. Phys. (Leipzig), 21: 272-80(1968).

The separation of variables in the total nuclear Hamiltonian neglecting the rotation of the nucleus as a whole (but not the "core rotation") is carried out. By frame transformation the operator of the interaction between rotational and intrinsic motions is derived for axial and non-axial nuclei. By using this operator the rotational spectra of deformed nuclei are examined. (auth)

**21398** COLLECTIVE CHARGE OSCILLATIONS IN ATOMIC NUCLEI. Krutov, V. A. (Leningrad State Univ.). Ann. Phys. (Leipzig), 21: 281-90(1968).

The low-lying states with negative parity in deformed even-even nuclei are considered as collective oscillations of the nuclear charge inside the nuclear matter. These oscillations are fully defined by the difference between charge and mass distribution in the nucleus, mainly by the difference between charge and mass density deformation. (auth)

**21399** ROTATIONAL MOTION OF DEFORMED NUCLEI. Krutov, V. A. (Leningrad State Univ.). Ann. Phys. (Leipzig), 21: 263-71(1968).

Collective motion in the nucleus is defined as change of the density distribution of nuclear matter in time. On the basis of this definition the Hamiltonian of nuclear rotation is obtained with moments of inertia corresponding satisfactorily to experimental data. The theory is easily applied to nuclei with non-axial equilibrium shape. For the latter the parameters of non-axiality are considerably smaller than in the Davydov–Filippov model. (auth)

**21400** INFLUENCE OF ELECTRONIC SHELL ON GAMMA RADIATION OF ATOMIC NUCLEI. Krutov, V. A.; Fomenko, V. N. (Leningrad State Univ.). Ann. Phys. (Leipzig), 21: 291-302(1968).

Additional de-excitation of the nucleus over the electronic shell is considered, the excited states of the electronic shell being intermediate in such de-excitation. (auth)

**21401** THEORY OF PHOTON SCATTERING BY NUCLEI AND THE DYNAMIC COLLECTIVE MODEL. Arenhovel, H.; Greiner, W. (Univ., Frankfurt am Main). Progr. Nucl. Phys., 10: 167-237(1969).

The dynamic collective model (DCM) unifies the surface (~1 MeV excitation energy) and giant resonance (15 to 25 MeV excitation energy) collective degrees of freedom and studies their mutual interaction. The theory of photon scattering by nuclei is summarized and developed, and some typical applications within the DCM are described. A short review of radiation theory is given; including the formalism for photon scattering. Scattering amplitudes and cross sections are derived, and the scattering amplitudes and density matrices are decomposed into irreducible components. Formulas for general polarizabilities are derived. Interesting cases such as the scattering of unpolarized or partially polarized radiation by unoriented nuclei, or of unpolarized radiation by oriented nuclei, are treated in detail. The various angular functions are explicitly given, and the formalism for photon scattering is applied to the DCM. The theory is given for dipole and quadrupole giant resonances of even–even and odd–even deformed nuclei and compared with experiment. The DCM is presented for spherical nuclei, together with a discussion of the elastic and various inelastic photon scattering cross sections. It is pointed out that detailed photon scattering experiments are needed, with such a resolution that some of the inelastic components can be separately measured. 56 references. (UK)

**21402** SPIN–ORBIT INTERACTION IN NUCLEI. Guman, V. N.; Sliv, L. A.; Kharitonov, Yu. I. Phys. Lett., 28B: 575-8 (Mar. 3, 1969).

The properties of the spin-orbit interaction in nuclei were investigated. It is shown that experimental splittings for both single particle and single hole levels may be described with the aid of unique two-body interactions between all particles in nuclei. The effective range of these forces is $r_0 = 0.8$ fm and the depth $v_{LS} = -15$ MeV. (auth)

**21403** GROWTH OF MULTIPOLE MOMENTS OF LOW-LYING NUCLEAR EXCITED STATES IN THE RANDOM PHASE APPROXIMATION: AN EXTENSION OF THOULESS' THEOREM. Dreizler, R. M. )(Univ. of Pennsylvania, Philadelphia); Klein, A.; Do Dang, G. Phys. Lett., 28B: 579-82(Mar. 3, 1969).

The structure of the conventional RPA, as one of the excitation energies of angular momentum J tends to zero, is shown to imply the unbounded growth of a static $2^J$-pole moment in the offending state. A possible non-linear generalization is indicated. (auth)

**21404** KONVERSIONSELEKTRONEN NACH DEM NEUTRON-EINFANG. (Conversion Electrons Following Neutron Capture). von Egidy, Till. Munich, Technische Hochschule, 1968. 120p.

A review of the measurements obtained up to 1955 of $\gamma$ radiation and conversion electrons from neutron capture is presented; and, after a brief enumeration of the requirements for a spectrometer for conversion electrons from neutron capture, the devices presently available are discussed. The measurement methods at the Munich spectrometer are described. The results obtained with the $\beta$ spectrometers of Moscow, Studsvik, Riga, and Munich are reported and compared. The most important contributions of these measurements to the knowledge of the structure of the atomic nucleus are compiled. Questions on the high-energy conversion coefficients are described. A statistical treatment of the total neutron capture radiation by means of a computer program is summarized. 313 references. (tr-auth)

**21405** KINEMATIKA YADERNYKH REAKTSII. IZDANIE VTOROE, PEREPABOTANNOE I DOPOLNENNOE. (Kinematics of Nuclear Reactions. Second Improved Edition). Baldin, A. M.; Gol'danskii, V. I.; Maksimenko, V. M.; Rozental, I. L. Moscow, Atomizdat, 1968. 456p.

A two-part presentation of the classical and quantum formulations of nuclear reaction kinematics is given. (D.C.W.)

**21406** UNAMBIGUOUS PHASE-SHIFT ANALYSIS OF NUCLEON–NUCLEON SCATTERING AT 400 MeV AND THE ENERGY DEPENDENCE OF PHASE SHIFTS ABOVE THE PION PRODUCTION THRESHOLD. Janout, Z.; Kazarinov, Yu. M.; Lehar, F.; Rozanova, A. M. (Joint Inst. for Nuclear Research, Dubna, USSR). Nucl. Phys., A127: 449-57(1969).

The phase-shift analysis of nucleon-nucleon scattering data at energies near 400 MeV was performed. A search for the solutions of the phase shifts was carried out for the maximal orbital momentum $l_{max} = 4$. Only the $^1D_2$ wave is assumed to have an imaginary part. Seven solutions were obtained in the region $\chi^2 \leq 1.5\chi^2_{\min}$. A detailed investigation has shown that six of them can be rejected with a probability of type I error smaller than 0.59%. Tables of phase shifts are given, and the energy dependence of phase shifts in the region 10 to 700 MeV are shown in the graphs. (auth)

**21407** RELATION BETWEEN THE AVERAGE REACTION CROSS SECTION AND THE TRANSMISSION COEFFICIENTS. Ullah, Nazakat (Univ. of Toronto). Phys. Rev. Lett., 22: 648-51(Mar. 31, 1969).

An expression is derived for the average reaction cross section using the two-channel, multilevel form of the unitary low-energy scattering matrix. It expresses the average cross section as a function of the transmission coefficients only and is valid for all values of the transmission coefficients. It is shown that over a wide range of the values of the transmission coefficients the values calculated using the Hauser-Feshbach expression agree very well with the present model. (auth)

**21408** AN ANALYSIS OF QUASI-ELASTIC (p,n) REACTIONS USING A REFORMULATED OPTICAL MODEL. Batty, C. J. (Rutherford High Energy Lab., Chilton, Eng.); Friedman, E.; Greenlees, G. W. Nucl. Phys., A127: 368-78(1969).

Angular distributions for (p,n) reactions exciting isobaric analogue states at 30 and 50 MeV were re-analyzed using a microscopic description along the lines recently used by Greenlees, Pyle and Tang for elastic nucleon scattering. The fits obtained with an entirely real interaction are always as good as, and in some cases appreciably better than, those obtained in a conventional macroscopic analysis and do not require any assumptions concerning the form factor of the interaction. In previous analyses, the form factors giving the best fit were sometimes of volume shape and sometimes of surface shape and in general included imaginary terms in the potential. (auth)

**21409** GENERATION AND STATISTICAL ANALYSIS OF SYNTHETIC CROSS SECTIONS. Hoffmann-Pinther, P. (Indiana Univ., Bloomington); Singh, P. P.; Lang, D. W. Nucl. Phys., A127: 241-69(1969).

A program was written to synthesize cross sections similar to those measured in nuclear experiments. These cross sections were analyzed in the spirit of the Ericson theory with the aim to determine the limitations associated with recovering the average values of quantities used to generate the synthetic cross sections. It is shown that the mean cross section, the mean width of nuclear levels and the autocorrelation coefficient can be measured with uncertainties that depend upon the size of the sample cross sections and that the normal experimental measurement is systematically low. The values of the above quantities as obtained by the statistical analysis of the cross section are compared with those

derived from theoretical predictions and reasonable agreement is found between the two. Quantitative effects of finite sample size, ratio Γ/D of nuclear level width to level spacing and number $\nu$ of open channels are demonstrated. (auth)

**21410** SUM RULE FOR NUCLEAR QUADRUPOLE INTERACTION. Robinson, E. J. (New York Univ., N. Y.). Phys. Rev. Lett., 22: 579-81(Mar. 24, 1969).

A sum rule relating the electric field gradient at the nucleus to elastic dipole matrix elements is derived. It appears to present a useful alternative to Sternheimer corrections. (auth)

**21411** NUCLEAR SPINS AND MOMENTS. Fuller, G. H. (Oak Ridge National Lab., Tenn. National Bureau of Standards, Washington, D. C.); Cohen, V. W. Nucl. Data, Sect. A, 5: 433-612(Mar. 1969).

A summarizing table of rounded-off nuclear-moment values, arranged by Z and A, is presented. This summary is based on experimentally determined values of the nuclear moments which have been listed in tables according to the specific spectroscopic or resonance technique used. References are given for all values quoted. Each table is preceded by a short introduction describing the experimental technique involved and the method of calculating the moments from the measured quantities. The cutoff date for the information included is August 1968. This tabulation supersedes Nuclear Moments, Appendix I to Nuclear Data Sheets, issued May 1965. (auth)

# REACTOR TECHNOLOGY

## Commercial Power Reactors

**21412** (APDA-NTS-22) REACTOR PERFORMANCE ON APPROACH TO POWER BY AUTOMATIC CONTROL: ENRICO FERMI REACTOR. Ziniuk, M. A.; Wilber, H. A. (Atomic Power Development Associates, Inc., Detroit, Mich.). Feb. 1969. 31p.

The results of tests conducted at the Fermi Fast Breeder Reactor at power levels of 13.3, 20, and 110 MW(t) for approach to power under control of the automatic loading programmes are presented. The experimental apparatus and equipment are described. The tests have provided data that confirm that temperature transients are within established limits, and that programme performance is satisfactory. (auth)

**21413** (DOCKET-50269-6) OCONEE NUCLEAR STATION, UNITS 1, 2, AND 3. [Preliminary Safety Analysis Report], Amendment 5. (Duke Power Co., Charlotte, N. C.). June 16, 1967. 16p. (DOCKET-50270-6; DOCKET-50287-3). Dep. CFSTI.

Additional information on the Oconee Power Reactor Unit 1 is given on the reactor control system and reactor containment system. Circuit diagrams for the control system are included. (D.C.C.)

**21414** (DOCKET-50320-9) THREE MILE ISLAND NUCLEAR STATION, UNIT 2. Preliminary Safety Analysis Report, Vol. 4. (Metropolitan Edison Co., Reading, Pa. Jersey Central Power and Light Co., Morristown, N. J.). Mar. 10, 1969. 375p. Dep. CFSTI.

Protection of Three Mile Island Power Reactor, Unit 2 structures from externally generated missiles is discussed. Scaled load plots for various containment structure loadings are shown. Normal operation and accident temperature profiles are shown as a function of containment shell thickness. Analytical procedures for calculating forces, moments, and shears for the base slab are described; elastic properties of sands used to fabricate the base slab are tabulated. Details of the containment vessel liner design are given. Containment penetrations and large openings are discussed; thermal gradients for the main steam line penetration are shown graphically. Corrosion inhibiting characteristics of the grouted tendon prestressing system are described. The analytical model used for seismic analysis of the reactor cooling system is detailed. Effects of postulated diversion of emergency-injection cooling water are analyzed; use of the alkaline sodium thiosulfate containment spray system is discussed. Capability of the Emergency Core Cooling System to subcool the core, thereby preventing significant steam generation after blowdown, is discussed. Potential hazards resulting from radiolytic and chemical hydrogen formation under post-accident conditions are evaluated; data are shown graphically. Emergency loadings of the diesel generator in bringing the reactor from normal operation to cold shutdown are tabulated. Closing time criteria for reactor building isolation valves are listed. Calculations for pressure vessel nvt are included. Research and development areas are summarized. Tritium generation and control are discussed. (M.L.S.)

**21415** (DOCKET-50320-10) THREE MILE ISLAND NUCLEAR STATION, UNIT 2. [Preliminary Safety Analysis Report], Amendment 6. (Metropolitan Edison Co., Reading, Pa. Jersey Central Power and Light Co., Morristown, N. J.). Mar. 10, 1969. 63p. Dep. CFSTI.

The relocation and redesignation of Oyster Creek Power Reactor, Unit 2 as Three Mile Island Power Reactor, Unit 2 is described. The ownership of Three Mile Island Power Reactor, Unit 2 by Jersey Central Power and Light and Metropolitan Edison as tenants in common is given as record; duties of each owner-member are delineated. Directors and principal officers of both companies are listed. Estimated construction costs are tabulated for the reactor. The 1967 Annual Reports are included for Jersey Central Power and Light Company, Metropolitan Edison Company, and, the parent company, General Public Utilities. (M.L.S.)

**21416** (GA-9237) 40-MW(e) PROTOTYPE HIGH-TEMPERATURE GAS-COOLED REACTOR POSTCONSTRUCTION RESEARCH AND DEVELOPMENT PROGRAM. Quarterly Progress Report for the Period Ending January 31, 1969. (Gulf General Atomic, Inc., San Diego, Calif.). Feb. 28, 1969. Contract AT(04-3)-314. 41p. Dep. CFSTI.

FISSION PRODUCTS—activity in Peach Bottom Unit 1 cooling system following 300 EFPD operation

HEAT TRANSFER SYSTEMS—fission product activity following 300 EFPD operation in Peach Bottom Power Reactor, solid

PEACH BOTTOM POWER REACTOR, UNIT 1—shutdown tests and inspections for, summary of Nov. 1968 to Jan. 1969
—fuel element power densities in, analysis of replacement
—control rods for, 300 EFPD boron burnup effects in inserted
—xenon decay and buildup following 300 EFPD in
—core and component materials behavior in, analysis following 300 EFPD of
—fuel elements for, analysis of 300 EFPD failed
—cooling system of, solid-fission-product activity following 300 EFPD in

REACTOR CONTROL ELEMENTS—reactivity worth changes of Peach Bottom Unit 1, during Core 1 operation

REACTOR FUEL ELEMENTS—power densities in Peach Bottom Unit 1 replacement
—failure of Peach Bottom Unit 1, during Core 1 operation

XENON—buildup and decay in Peach Bottom Unit 1 following 300 EFPD operation (H.D.R.)

**21417** (GAMD-9187) LUMPED BURNABLE POISON RODS FOR THE PSC CORE. Malakhof, V.; Simon, W. A. (Gulf General Atomic, Inc., San Diego, Calif.). Feb. 20, 1969. Contract AT-(04-3)-633. 30p. Dep. CFSTI.

Flux self-shielding factors for lumped burnable poison rods in the initial 330 MW(e) PSC core and the reload segments were calculated with the two-dimensional transport theory code 2DF. The effect of fuel discontinuities and the mutual shadowing between the burnable poison rods on the self-shielding factors were investigated. The self-shielding factors were used to determine the worth of the burnable poison rods in diffusion theory calculations. The effect of various methods of lumped burnable poison "smearing" on the worth of a control rod pair was also investigated. 6 references. (auth)

**21418** (ORNL-TM-2447) THE DEVELOPMENT AND USE OF A RETRIEVAL SYSTEM FOR SAFETY DESIGN INFORMATION ON NUCLEAR POWER PLANTS (CHORD-S). Browning, W. E. Jr. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 60p. Dep. CFSTI.

An information retrieval system (CHORD-S: Computer Handling of Reactor Data–Safety) is described which provides access to a file of data on the safety aspects of the design of commercial nuclear power plants by interactive dialogue through a remote console. The system was developed for evaluation by AEC's Division of Reactor Licensing, and may be useful to others concerned with reactor safety. The file presently can supply data selected from about 625 items of information for each of 10 to 57 nuclear power plants, depending upon the type of information. The system is currently implemented on an IBM 360/50-65 at the Computing Technology Center at Oak Ridge and is accessible through several remote consoles located throughout the Oak Ridge area, and through one console located in the AEC offices in Bethesda, Maryland. (auth)

**21419** (RISO-M-775) ATOMIC ENERGY IN SWITZERLAND. Bardram, E. G. (Danish Atomic Energy Commission, Risoe, Research Establishment). Aug. 28, 1968. 28p. (In Danish). Dep.

One of the main activities of Swiss industry is supplies for power stations. The substantial effort, which has been made by the different industries as well as by government, towards enabling the production of equipment for nuclear power stations is described, and major equipment orders for power stations in U. S. as well as for the three power stations being built in Switzerland are mentioned. Swiss electricity generation has up to the present been based almost exclusively on hydropower. This source of energy is already extensively exploited, so other sources of energy are required to cover the increases in demand. Nuclear energy has been chosen for the greater part of the expansion. A favorable combination is obtained by adding base loaded nuclear power stations to the existing energy supply system with its capability to store energy. Nuclear power stations are also favored because of their possibility of keeping fuel reserves for long periods, and because they do not pollute nature. 32 references. (auth)

**21420** (TID-24966) NUCLEAR EDUCATION AND TRAINING PROGRAMS OF POTENTIAL INTEREST TO UTILITIES. (Division of Nuclear Education and Training (AEC), Washington, D. C.). Dec. 1968. 52p. Dep. CFSTI.

A compilation of education and training programs of potential interest to nuclear power utility management and technical staffs

is presented. These programs are being provided by various institutions of higher education, reactor vendors, and consulting firms. (W.H.K.)

**21421** (WAPD-T-2152) COMPARISON OF PHYSICS MEASUREMENTS AND WEIGHTED RESIDUAL SYNTHESIS CALCULATIONS FOR THE SHIPPINGPORT PWR CORE 2 SEED 1 THROUGH DESIGN LIFE. Smith, Francis E. (Bettis Atomic Power Lab., Pittsburgh, Pa.). Nov. 1968. Contract AT(11-1)-Gen-14. 20p. (CONF-681101-14). Dep. CFSTI.

From International Conference on the Constructive Uses of Atomic Energy, Washington, D. C.

Weighted residual flux synthesis methods have been employed to calculate flux distribution and depletion effects in the second Shippingport seed-blanket reactor through the design life of the first seed. Eigenvalues of calculations performed using measured critical rod bank positions showed no identifiable trends of variation with lifetime. The calculated power distribution between seed and blanket agreed with measured data within the experimental uncertainties. Measured and calculated axial flux distributions have also shown good agreement. 7 references. (auth)

**21422** TECHNIQUES ELECTRONIQUES DU CONTROLE DES REACTEURS NUCLEAIRES. (Electronic Techniques for Nuclear Reactor Control). Weill J. Gif-sur-Yvette, Centre d'Etudes Nucleaires de Saclay, 1967. 112p.

Basic nuclear physics of reactor control and control systems is reviewed; neutron multiplication, prompt and delayed neutrons, neutron sources and reactor response, temperature effects, and reactor poisoning are discussed briefly. Neutronic and thermal power measurement techniques are described. The use of neutron detectors in reactor control is outlined; the various types of amplifiers are described. Techniques for period and reactivity measurements are discussed; equations defining the reactor transfer function are given. Automatic reactor control methods are outlined. Reactor protective circuitry is discussed in detail. Block diagrams and schematics for reactor control and safety instrumentation are included. 124 references. (M.L.S.)

**21423** CONTAINMENT VESSEL. Geiger, G. (Eidgenoessiche Technische Hochschule, Kleindoettingen, Switzerland). Neue Tech., 10: 161-70(1968). (In German).

Description of double containment of the nuclear power station Beznau I is presented. The special problems concerning choice of materials, manufacture and erection are discussed. The procedures for leak rate- and pressure control are described. (auth)

**21424** RADIATION PROTECTION MONITORING OF THE BEZNAU ATOMIC POWER PLANT. Martinc, A. (Landis and Gyr AG, Zug, Switzerland). Neue Tech., 10: 156-60(1968). (In German).

The described example of the radiation monitoring equipment of the nuclear power station Beznau I indicates that a complex control system can be established by the rational application of a relatively few number of proven components. Problems are quite similar for other nuclear power stations. (auth)

**21425** FUEL HANDLING AND STORAGE EQUIPMENT OF THE BEZNAU NUCLEAR POWER STATION. Ribaux, P. A. (Charmilles Engineering Works Ltd., Geneva). Neue Tech., 10: 152-5(1968).

Description of the fuel handling and storage equipment for the Beznau nuclear power station is presented. (auth)

**21426** NUCLEAR POWER STATION BEZNAU. Aemmer, F.; Elmiger, E. (Nordostschweizerische Kraftwerke AG, Baden, Switzerland). Neue Tech., 10: 130-2(1968). (In German).

A general description of the Beznau Power Reactor Unit 1 is presented as an introduction to more detailed papers on the various power plant systems. (J.M.J.)

**21427** THE 54 MWe DODEWAARD NUCLEAR POWER PLANT. TECHNICAL AND HISTORICAL SURVEY. Wassenaar, K. Atoomenergie Haar Toepass., 11: 31-37(Feb. 1969).

A general description of the Dodewaard Power Reactor is presented. The site and site preparations are described. The plant lay-out is illustrated. Design specifications for the reactor are listed. (D.C.C.)

**21428** ENERGY SITUATION IN THE NETHERLANDS. Muysken, M. Atoomenergie Haar Toepass., 11: 27-30(Feb. 1969).

The domestic consumption of coal, natural gas, nuclear fuel, and oil in the Netherlands is described. The present and predicted consumptions of fuels are illustrated for 1960 to 1980. The economics and the supply-and-demand factors concerning fuels are analyzed. The present and predicted consumptions of fuels by the utility companies in the Netherlands are illustrated for 1960 to 1980. 8 references. (D.C.C.)

**21429** REPORT BY THE COMMISSION CONSULTATIVE POUR LA PRODUCTION D'ELECTRICITE D'ORIGINE NUCLEAIRE ON THE PERSPECTIVES FOR DEVELOPMENT OF NUCLEAR POWER PLANTS IN FRANCE, APRIL 1968. Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 74, 5-34(Nov.-Dec. 1968). (In French).

The overall study of the French nuclear program and nuclear industry is included. The various programs of other countries are considered with respect to the French economy and industrial alignment; the British advanced gas cooled reactor concept, the US light water reactor development, and the heavy water reactor system are compared with the natural uranium-graphite-gas systems. The bases and policies for the five-year plan are discussed; rationale is outlined. Appendices tabulate the nuclear power stations in France, make predictions for supply and demand of electricity, and tabulate the expenses and costs required for the various reactor systems. Uranium availability and enrichment is considered. Export-import problems are discussed briefly. (M.L.S.)

**21430** DEVELOPMENT IN EUROPE OF THE GENERATION OF ELECTRICAL POWER FROM NUCLEAR ORIGIN DURING THE FIRST HALF OF 1968. Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 74, 74-86(Nov.-Dec. 1968). (In French).

Production of nuclear-generated power in Europe during the first half of 1968 is summarized by country. Summaries are given for: Belgium, Denmark, Germany, Spain, France, Italy, the Low Countries, Norway, Switzerland, Sweden, and Great Britain. (M.L.S.)

**21431** STRESS ANALYSIS OF STRUCTURES SUBJECTED TO AIRCRAFT IMPACT FORCES. Riera, Jorge D. (Gilbert Associates, Inc., Reading, Pa.). Nucl. Eng. Design, 8: 415-26 (1968).

Total reaction versus time relationships expected in case of an accidental impact of large commercial aircrafts against a rigid surface are presented. Maximum response curves for an elastic, undamped, one-degree of freedom system are evaluated and examples of dynamic analyses of representative reinforced or prestressed concrete structures in nuclear power plants are discussed in some detail. The above information and results serve as a basis for proposed simplified approaches. 9 references. (auth)

**21432** PRESTRESSING SYSTEMS FOR SECONDARY AND PRIMARY CONTAINMENT STRUCTURES. Kulka, Felix (Lin, Kulka, Yang and Associates, San Francisco). Nucl. Eng. Design, 8: 435-9(1968).

Prestressing systems used in primary and secondary concrete containment structures are reviewed, along with the implications of various systems with respect to design construction and surveillance. There are illustrations of existing installations and testing. Bonded and non-bonded post-tensioning for nuclear containment structures is discussed. (13 references). (auth)

**21433** ATOMIC POWER PLANT AT JASLOVSKE BOHUNICE. Patrovsky, V. Skoda Rev., No. 6, 10-21(1968). (In Czech).

A description of the Czechoslovak heavy water-moderated, $CO_2$-cooled, 110 MW(e) reactor is presented. (UKAEA Info. Bull.)

**21434** CONTROL OF BROWN-BOVERI TURBINES FOR THE OPERATION OF A PRESSURIZED WATER REACTOR. Panis, L. M.; Weehuizen, F.; Scharff, W. (Brown, Boveri and Cie. AG, Baden, Switzerland). Neue Tech., 10: 133-8(1968). (In German).

Turbine control has been selected as an example for discussion. A comprehensive description of components and their function is not presented, but rather the important factors which must be considered for the satisfactory operation of the turbosets in association with a pressurized water reactor are analyzed. (auth)

**21435** EARTHQUAKES AND NUCLEAR POWER. Novick, Sheldon. Sci. Citizen, 10: 230-41(Nov. 1968).

Local opposition to the projected site of a nuclear power reactor near an earthquake fault zone, the controversy which followed, and withdrawal of plans to construct the reactor at that site are discussed. After more than 6 yr of planning, the Pacific Gas and Electric Co. on October 30, 1964 announced that it had abandoned plans for a nuclear-powered electric generating plant at Bodega Bay, California. The site, only 1000 ft west of the San Andreas fault, was dropped as the location for a 325 MW nuclear plant because of fears that hazardous radiation would be released in case of a severe earthquake. (BBB)

**21436** USE OF A REACTIMETER IN REACTOR WITH CHEMICAL CONTROL. Brosson, Michel; Gueben, Maurice. Ind. At., 13: No. 1-2, 27-34(1969). (In French).

Following a brief description of the nuclear center of the Ardennes (a pressurized water reactor, chemically controlled), a

number of theoretical considerations are expounded in connection with nuclear measurements. The measurement technique utilized with the reactimeter for measurements of reactivity at zero power and in potential is presented. A series of other possible utilizations of this apparatus, together with a certain number of characteristic recordings of reactivity in terms of time, are described. (auth)

**21437** HIGH PRESSURE STEAM TURBINE HOUSING OF 13 PERCENT CHROMIUM STEEL FOR THE BEZNAU PRESSURIZED WATER REACTOR. Lueling, H. (Georg Fischer Aktiegesellschaft, Schaffhausen, Switzerland). Neue Tech., 10: 149-51 (1968). (In German).

The problems discussed include: determination of the quality demands for steel castings in reactor turbines DIN 17245; corrosion and erosion phenomena occurring under wet steam; and casting experiences for big 13%-chromium steel cylinders for steam turbines. (auth)

**21438** THE MANUFACTURE OF THE PRESSURIZER AND THE PRIMARY CIRCULATION PIPING FOR THE BEZNAU ATOMIC POWER PLANT. Straub, H. (Gebrueder Sulzer AG, Winterthur, Switzerland). Neue Tech., 10: 138-48(1968). (In German).

A short description is given of the pressurizer and the pipes for the primary cooling system. Special attention is given to certain aspects in relation with projecting, manufacture, control and erection. (auth)

**21439** DESIGN AND CONSTRUCTION OF THE THTR-PROTOTYPE NUCLEAR POWER PLANT. Hennings, U. (BCC/Krupp, Mannheim, Ger.); Schmiedel, F. Atomwirt., Atomtech., 14: 118-21(Mar. 1969). (In German).

A general description of the Thorium High Temperature Reactor (THTR) is given; general design characteristics are tabulated. Brief descriptions of the prestressed concrete reactor vessel, the coolant blowers, and the steam generators are given; some typical data are tabulated. (M.L.S.)

**21440** NUCLEAR SAFETY OF THE THTR-PROTOTYPE NUCLEAR POWER PLANT. Baust, E. (Brown Boveri/Krupp Reaktorbau GmbH., Mannheim, Ger.). Atomwirt., Atomtech., 14: 122-4(Mar. 1969). (In German).

The various safety aspects of the Thorium High Temperature Reactor (THTR) are described. Activity of the primary cycle is discussed for both usual and abnormal operation conditions. External dose rates are shown as a function of distance from the reactor under normal operation conditions. Maximum activity release under hypothetical accident conditions is discussed. (M.L.S.)

**21441** CORE PHYSICS CALCULATIONS FOR THE THTR. Harder, H. (BCC/Krupp, Mannheim, Ger.). Atomwirt., Atomtech., 14: 124-5(Mar. 1969). (In German).

The techniques used for physics calculations for the Thorium High Temperature Reactor (THTR) are described briefly; calculated core physics parameters are tabulated. (M.L.S.)

**21442** OPTIMIZATION OF THE THTR FUEL CYCLE. Schloesser, J. (BCC/Krupp, Mannheim, Ger.). Atomwirt., Atomtech., 14: 125-6(Mar. 1969). (In German).

The fuel cycle for the Thorium High Temperature Reactor is discussed; cycle sequences are listed. The effects of the thermal power density in-core are assessed. Fuel cycle costs are shown for $^{235}U$ and $^{232}Th$ pebbles as a function of year. (M.L.S.)

**21443** UTILIZATION OF PLUTONIUM AS FUEL IN THE THTR. Brandes, S. (Kernforschungsanlage, Juelich, Ger.); Markowski, B. Atomwirt., Atomtech., 14: 128-31(Mar. 1969). (In German).

Future use of plutonium as fuel in the Thorium High Temperature Reactor (THTR) is discussed. Reactor operations parameters are tabulated for plutonium fuel; fuel cycle costs are calculated for pebble reactors. Projected calculations for a plutonium fueled THTR are given for the 1970 through 1985 period; all data are tabulated. (M.L.S.)

**21444** COMPUTER PROGRAM TO SUPPORT THE PLANNING OF NUCLEAR POWER PLANTS. Luetkens, L. N. Atomwirt., Atomtech., 14: 131-4(Mar. 1969). (In German).

A computer program for the information centralization and project control for the Thorium High Temperature Reactor (THTR) Project is described. The overall organization of the computer program is discussed. Machine handling of the technical data and the program limitations and addresses are outlined. Input/output requirements and format are described; control instruction trees are shown. The program is written in FORTRAN IV and requires around 2500 cards. (M.L.S.)

**21445** REPROCESSING COSTS FOR THTR ELEMENTS BY VARIOUS PROCESSES. Brandes, S. (Kernforschungsanlage, Juelich, Ger.); Krahe, J.; Mueller, F. Atomwirt., Atomtech., 14: 135-8(Mar. 1969). (In German).

Effects of cost factors of various reprocessing techniques on the fuel cycle economics of the Thorium High Temperature Reactor are evaluated. Dependence of the annual fuel cycle cost on fuel cooling time and wastage is shown graphically. Thorium recovery is discussed. (M.L.S.)

**21446** EUROPEAN ATOMIC INDUSTRY AND ITS MARKET. Ehrentreich, J.; Pantleon, M. Atomwirt., Atomtech., 14: 138-42(Mar. 1969). (In German).

Control rods and control rod drives for European reactors are discussed; control rod materials are described briefly. Control rod and control rod drive data are tabulated for European gas cooled, boiling, and pressurized water reactors. Manufacturers and supply firms are listed for Belgium, Germany, France, Italy, The Netherlands, and Luxembourg. (M.L.S.)

## Power Reactor Development

*Refer also to abstracts 20560, 21538, and 21539.*

**21447** (AECL-3251) IMMEDIATE RELATION OF ING TO FAST BREEDER REACTOR PROGRAMS. Lewis, W. Bennett (Atomic Energy of Canada Ltd., Chalk River (Ontario)). Jan. 1969. 23p. (DM-97). Dep. CFSTI. CAN $0.50.

The use of fast neutron ING facilities in the development of liquid Na-cooled fast breeder reactors is described. The reactor facilities of DFR, EBR-2, and FFTF are described in terms of usefulness to the development of liquid Na-cooled fast breeder reactors. 11 references. (D.C.C.)

**21448** (AI-CE-Memo-11) HEAVY WATER ORGANIC COOLED REACTOR. THREDES: ATOMICS INTERNATIONAL THERMAL REACTOR DESIGN SYSTEM. Blaine, R. A. (Atomics International, Canoga Park, Calif. Combustion Engineering, Inc., [Windsor, Conn.]). [nd]. Contract AT(38-1)-130. 170p. Dep. CFSTI.

THREDES is a scientific applications programming system written in the FORTRAN IV language for the IBM 7094/360 computers. Incorporated in this system are the necessary modules to perform parametric design studies of thermal reactors including the thermal cell homogenization (BAM), the fast spectrum calculation (FØRM), reactor diffusion theory (FØG), and zero dimensional burnup (KINDLE) calculations. 39 references. (auth)

**21449** (NIJS-P-229) SELECTION OF A TYPE AND PLANT SIZE FOR A REFERENCE REACTOR FOR NUCLEAR POWER STATION KRSKO. Bernot, N. (Nuklearni Institut Jozef Stefan, Ljubljana (Yugoslavia)). Sept. 1968. 72p. (In Slavic). Dep.

Selection of a reference steam generator for the intended nuclear power Station on Krško Polje has been made on the basis of the Canadian General Electric proposal to Poslovno združenje energetike for a nuclear reactor type "Venture." The main technical and economic features of the proposed nuclear power station to be built in the north-western part of Yugoslavia during the period 1970-80 are presented. Main technical features and problems as well as broad economic features of different reactor types now in operation, in construction, or in approved projects, and outlooks for further development in the next 10 years are reviewed. (auth)

**21450** (NP-tr-1730) THE MULTI-PURPOSE RESEARCH REACTOR MZFR. Brandl, J. Translated by C. R. Brightmore for Atomic Energy Research Establishment, Harwell, Eng., from Atomwirtschaft, 8: 257-9(1963). 8p. Dep.

The MZFR was designed as both a testing reactor and a prototype for a nuclear power station using a heavy water moderated natural uranium reactor. The reactor, experimental facilities and program, and association with the Karlsruhe Research Center are briefly described. (H.D.R.)

**21451** (ORNL-4344) MOLTEN-SALT REACTOR PROGRAM SEMIANNUAL PROGRESS REPORT FOR PERIOD ENDING AUGUST 31, 1968. (Oak Ridge National Lab., Tenn.). Feb. 1969. Contract W-7405-eng-26. 333p. Dep. CFSTI.

Progress is reported on the Molten Salt Reactor Program. Titles of the topics reported include: Molten-Salt Reactor Experiment; MSBR Design and Development; Chemistry; Molten-Salt Irradiation Experiments; Materials Development; and Molten-Salt Processing and Preparation. Separate abstracts are included for each of the 6 parts presented. (D.C.C.)

*For abstracts of individual sections see: 19693, 19829, 20524, 21452, 21484, and 21501.*

**21452** (ORNL-4344, pp 53-108) MSBR DESIGN AND DEVELOPMENT. (Oak Ridge National Lab., Tenn.).

HEAT EXCHANGERS (LIQUID-LIQUID)—design parameters for 1000 MW(e) single-fluid MSBR vertical single-pass counterflow
MOLTEN SALT BREEDER REACTOR—buildings for 1000 MW(e) single-fluid, layout diagrams of
—cooling system flowsheet for 1000 MW(e) single-fluid
—core for 1000 MW(e) single-fluid
—control rod drives for 1000 MW(e) single-fluid
—heat exchangers for 1000 MW(e) single-fluid, description of vertical single-pass counterflow
—physics measurements for 1000 MW(e) single-fluid
—control system parameters for single-fluid, analog simulation of
—fuels for single-fluid, heat transfer characteristics of molten salt
PUMPS—design requirements for single-fluid MSBR fuel system
REACTOR CONTROL ELEMENTS—drives for 1000 MW(e) single-fluid MSBR
REACTOR FUELS—heat transfer characteristics of molten salt
SODIUM FLUOROBORATES—pumping characteristics of
XENON ISOTOPES Xe-135—concentration in 1000 MW(e) single-fluid MSBR fuel system (D.C.C.)

**21453** FAST BREEDER REACTOR POWER STATIONS. Moore, R. V. Atom, No. 149, 59-74(Mar. 1969).

A review is presented under the following headings: present position; U, Th and Pu availability and utilization; fast reactor benefits and characteristics; experimental plants, including the Dounreay Fast Reactor (DFR); Prototype Fast Reactor (PFR) power station design and progress; commercial fast reactor power stations; trend of nuclear generating costs; and conclusions. (UK)

**21454** LAWS AND REGULATIONS RELATING TO ATOMIC ENERGY. Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 74, 42-5(Nov.-Dec. 1968). (In French).

The latest (October 30, 1968) French laws governing civil responsibilities in the area of nuclear energy are given. Twenty four articles defining areas and phases of responsibility, rights, and coverages are listed. The scope of the law covers all nuclear installations, both civilian and military. Indemnification provisions are defined. Some special provisions concerning nuclear powered ships are outlined. (M.L.S.)

**21455** FRENCH LEGISLATION RELATING TO CIVIL NUCLEAR LIABILITY. Reyners, Patrick (OECD, Paris). Bull. Inform. A.T.E.N. (Ass. Tech. Energ. Nucl.), No. 74, 35-40(Nov.-Dec. 1968). (In French).

The development of the international nuclear law bases is outlined; guidelines used in establishing the basic principles are listed. The concepts of nuclear risk and civil responsibility are discussed. The French law relative to civil responsibility in the area of nuclear energy is related; basic terms and concepts are defined. Responsibility, reparation, and indemnification are discussed. Juridical competence is assessed. (M.L.S.)

**21456** ATOMKERNREAKTOREN. (Nuclear Reactors). Kliefoth, Werner. Schriftenreihe des Deutschen Atomforums. Heft 2. Bonn, Deutschen Atomforum e.V., 1964. 110p.

The basic physics of the nucleus is reviewed; the fission process is discussed. Each of the research and power reactors in the German Federal Republic is described; either diagrams or pictures of each are shown. A tabulation of all reactors, up to December 1967, is included. (M.L.S.)

**21457** FAST BREEDER REACTOR. S. Afr. Mining Eng. J., 79: 605-6(Sept. 13, 1968).

The development of the fast breeder reactor in U. K. is described. An experimental version has been in successful operation since 1959 at Dounreay, Scotland, where a large prototype of 250 MW(e) is under construction. The latter is expected to be generating electricity in 1971. The experience gained in its operation should lead to commercial units for sale in the 1970's. Then there should be larger units of up to some 1000 MW(e), likely to be introduced into the British electricity generating system before 1980, and then units on an increasing scale (complementary at first with advanced thermal reactors) to meet electrical power requirements which may approach 50,000 MW(e) by 1985 and well over 100,000 MW(e) by the end of the century. Capital costs of future large fast breeder reactors are similar to the forward estimates for fully developed thermal reactors available at the same time. Fast reactors can convert 75% of the total energy available in nuclear fuel compared with not more than 2% in the case of thermal reactors. Fuel costs will be cut by as much as a half, after allowing for the cost of reprocessing and refabrication. Early experimental work in Britain is reviewed. (BBB)

**21458** SURVEY OF THE NUCLEAR POLICY OF THE EUROPEAN COMMUNITY. Euratom Rev., 7: 129-54(1968).

The current state of affairs in the Euratom nuclear policy is analyzed, and the disturbing nature of underlying factors in this policy is discussed. Problems of research and technology and of energy and industrial development are examined, and guidelines which should be adopted to remedy the deteriorating situation are detailed. (H.D.R.)

**21459** NUCLEAR POWER STATIONS. Schmidt, Gerhard (Berliner Kraft- und Licht (Bewag)-AG, Berlin). Brennst.-Waerme-Kraft, 21: 83-6(Feb. 1969). (In German).

The activities of 12 countries in nuclear power plant development are briefly summarized. Thermal reactors, breeders, economics, nuclear plant construction, and the activities of the Kurtschatow Institute in Moscow are discussed. (H.D.R.)

**21460** THE DEVELOPMENT OF NUCLEAR REACTORS. Stiennon, G. (CEN, Mol, Belgium). Bull. Belgicatom, 13: No. 3/4, 5-8(Oct.-Dec. 1968). (In French).

Power reactor development in Europe and the U. S. is summarized and projections of future utilization of advanced converters and breeders are reviewed. (H.D.R.)

## *Kinetics and Dynamics*

**21461** (AEEW-R-603) FURTHER OPTIMIZATION STUDIES OF EXPERIMENTAL DYNAMIC RESPONSES MEASURED ON THE HTGC DRAGON REACTOR. Cummins, J. D. (Atomic Energy Establishment, Winfrith (England)). Apr. 1968. 60p. (DP-Report-563). Dep. CFSTI. UK 8s. 0d.

Measurements of the dynamics of the HTGC Dragon reactor and optimization of a mathematical model which represents the reactor are described. The experimental response to an impulse, step or periodic sine wave change in reactivity was processed and compared with a similar response from the model. In other studies the result of a binary cross correlation experiment (effectively an impulse response input) was processed as a frequency response and this experimental frequency response was compared with the frequency response from the mathematical model. The optimum values of parameters obtained for different forms of perturbing signal and for different methods of processing were compared, and the optima obtained were related to the problem of parameter estimation. (auth) (UK)

**21462** (GA-8943) POSSIBLE INSTABILITIES IN A THERMIONIC REACTOR WITH NEGATIVE REACTIVITY COEFFICIENTS. Heath, C. A. (Gulf General Atomic, Inc., San Diego, Calif.). Sept. 19, 1968. Contract AT(04-3)-167. 10p. (CONF-681035-2). Dep. CFSTI.

From IEEE Thermionic Conversion Specialist Conference, Framingham, Mass.

An analysis of stability in a thermionic reactor has been performed which includes the delayed collector and structure coefficients. This analysis shows that, for certain ranges of coefficients, it is possible for a thermionic reactor to show open-loop oscillatory instability with all negative coefficients. This phenomenon exists for small ($< 6 \times 10^{-7}$/°K) negative values of the temperature coefficient of the emitter material. An increase in the magnitude of the negative coefficient of the collector and structure material does not improve the stability of the system and for some cases will lead to oscillatory instability. Proposed methods of increasing the negative coefficient of the emitter are discussed. (auth)

**21463** (EUR-4208) DEPOSITION OF FISSION ENERGY IN AN ORGEL-TYPE REACTOR. Haytink, B.; Schmidt, E. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1968. 36p. Dep.

The source strengths for the individual kinds of energy liberated by the fission process are summarized. A calculation model for their deposition in an ORGEL-type reactor is explained, and the numerical results for the 250 MW(e) ORGEL prototype are given which will permit the evaluation of the decomposition rates for the organic coolant in this reactor type. 15 references. (auth)

**21464** (EURFNR-608) PHYSICS INVESTIGATIONS OF URANIUM-FUELED FAST STEAM-COOLED REACTORS IN SNEAK, ASSEMBLIES 3A-0, 3A-2, 3A-3. Schroeder, R. (comp.) (Kernforschungszentrum, Karlsruhe (West Germany)). Oct. 1968. 87p. (KFK-847; EUR-3721). Dep.

Work performed under United States-Euratom Fast Reactor Exchange Program.

Experiments on the SNEAK-3A series of assemblies are de-

scribed for the physics characteristics of fast steam-cooled uranium reactors of about 500 l core volume at operating steam density. The steam was simulated by polyethylene foils. Two of the assemblies, corresponding to 40% (3A-1) and to 100% (3A-2) of the normal coolant density, have been investigated in considerable detail. Two more assemblies, investigated in less detail, have been obtained by voiding part of the core of assembly 3A-1 (viz. 3A-0) and by doubling the thickness of the polyethylene foils in part of the core of assembly 3A-2 (viz. 3A-3). The experiments done at assembly 3A-0 and those done at assemblies 3A-2 and 3A-3 are discussed. Many of the experimental data are of direct interest to the designer of a steam-cooled fast breeder reactor, e.g., the critical mass, the reactivity coefficient of the coolant density and the ratio of the capture rate of $^{238}U$ to the fission rate of $^{235}U$ as a function of position, that is closely related to the breeding ratio. Others, like the Doppler coefficient, are measured under conditions different from those in an actual fast reactor, but the comparison of experiment and calculation provides a valuable insight in the state of the art of calculating this effect. All experimental results obtained were carefully compared with calculations with the intention to localize errors in the cross section sets used as well as to check the theoretical models applied. 38 references. (auth)

**21465** (IDO-17217) SINBAD: A SPACE-INDEPENDENT NUCLIDE BUILDUP AND DEPLETION CODE. Putnam, G. E. (Phillips Petroleum Co., Idaho Falls, Idaho. Atomic Energy Div.). Jan. 1969. Contract AT(10-1)-205. 102p. Dep. CFSTI.

SINBAD computes the time-dependent concentrations of nuclides on the basis of a few (one to four) neutron energy group, space-independent model of a nuclear reactor. Production and depletion by fission, capture, and radioactive decay processes are considered. For 32K computers, the code presently allows up to 250 nuclides, three sets of fission yields, and four daughters (branches) from a parent nuclide. About 0.03 second of IBM 7044 time is required per nuclide (for each time point computed) with the fairly complex schemes typical of fission products. The SINBAD code presently exists in Fortran IV and Fortran 63 versions. (auth)

**21466** (RD/B/N-1304) FRIC: MULTIGROUP POINT MODEL OF THE FAST REACTOR. Clarke, R. H. (Central Electricity Generating Board, Berkeley (England). Berkeley Nuclear Labs.). Jan. 1969. 28p. Dep.

FRIC is a FORTRAN IV program written for the IBM 360/75 to solve the multigroup diffusion equations at a point, using a standard UKAEA 35 group fast reactor library. The multiplier can be put on a variety of terms so that buckling, fission source, material composition and prompt neutron decay searches are available. The program will provide condensed cell-averaged data, either using the eigenvector calculated, or over a spectrum read in. In addition these data can be punched out in the form required by CRAM. The fractional breeding gain and the reactivity contribution of each group are printed out with the breeding gain of the cell as a whole. (auth) (UK)

**21467** (RISO-M-786) FORMULATIONS AND SOLUTIONS OF XENON OVERRIDE PROBLEMS FOR THERMAL REACTORS WITH SPECIAL REFERENCE TO PRACTICABLE RELEVANCE AND PHYSICAL FEASIBILITY. Gottschalk, Georg (Danish Atomic Energy Commission, Risoe, Research Establishment). Aug. 1968. 62p. Dep.

The classical formulations of Xe override problems for thermal neutron reactors are made for research reactors only, and they contain only crude constraints on the variables, which causes steep power gradients and temperature gradients. Therefore the problems have been reformulated with reference to power reactors as well, and to physical feasibility. A description is given of the classical and the new formulations and solutions of Xe override problems. The computer code XEDYPNY (AEK Program No. 499) is evaluated to solve these problems. (auth) (Denmark)

## Control Systems

**21468** SELF-ADAPTING SYSTEM AND POSSIBILITY OF AUTOMATIC OPTIMUM POWER REGULATION OF NUCLEAR REACTORS. Bajanescu, Titu I. (Academia R.P.R., Bucharest). Tehnika (Belgrade), 23: 752-6(1968). (In Serbo-Croatian).

After a brief classification, the original scheme of an analog model which can optimize automatically the power control of a nuclear reactor is given. The scheme given is an adaptation of the Corbin method. (tr-auth)

**21469** MASTERING OF THE DESIGN OF AUTOMATION OF THE TECHNOLOGICAL PROCESSES AND SYSTEMS IN NUCLEAR POWER STATIONS. Sivjakov, Vladimir. Nukl. Energ., 5: No. 2, 14-16(1968). (In Serbo-Croatian).

Mastering the design of automation of the technological processes and systems in nuclear power stations, and an assessment of the results obtained in the mathematization and analysis of the processes by use of the computer technique are discussed. (auth)

## Shielding

*Refer also to abstract 20975.*

**21470** TYPICAL DESIGN PROBLEMS AND SOLUTIONS FOR PRESTRESSED CONCRETE CONTAINMENT STRUCTURES. Wahl, Howard W. (Bechtel Corp., San Francisco). Nucl. Eng. Design, 8: 471-86(1968).

Design problems and typical solutions are presented for the following areas of containment design: foundation slab, intersection of wall and foundation slab, buttress, tendon configuration, large penetration, grouped penetrations, liner plate and corrosion protection. The solutions are presented by discussion and illustrations of possible alternatives with their advantages and disadvantages if applicable. (auth)

**21471** CONSTRUCTION TECHNIQUES FOR PRESTRESSED CONCRETE PRESSURE VESSELS. Gerwick, Ben C. Jr. (Ben C. Gerwick, Co., San Francisco). Nucl. Eng. Design, 8: 460-6 (1968).

Material selection, mix design, placement, temperature control, and curing of concrete are discussed. Liners and cooling tubes, construction techniques, anchoring, and prefabrication are covered. Other subjects discussed are the forming and placement of concrete — buttresses, anchorages, construction joints; conventional reinforcement — placement; penetrations; prestressing tendons — ducts, installation tendons, anchors, placement and stressing, corrosion protection; and precast concrete segmental construction. 5 references. (auth)

**21472** PRESTRESSED CONCRETE PRESSURE VESSELS: TWO-DIMENSIONAL THERMOELASTICITY COMPUTER PROGRAM. Launay, P.; Charpenet, G.; Vouillon, C. (CITRA, Paris). Nucl. Eng. Design, 8: 443-59(1968).

The development of a thermoelasticity code (breaking away from the limitative hypothesis of the thin shells theory) to predict the behavior of two models of prestressed concrete pressure vessels which were tested in CHINON and which have resulted in the construction of the most advanced French type of graphite-moderated gas-cooled reactor named BUGEY I is described. This code computes in an axi-symmetrical plane, or translative elastic solid, the temperature and thermal flux vector distribution and thereafter displacement vector and stress tensor. This solid can be of an arbitrary shape, nonhomogeneous and submitted to a set of conditions (due either to the state of the solid itself, interaction between several of its points or to external action) which are either constant loads (heat sources, forces, pressure...) or elastic ones (thermal resistances, springs, membranes,...) and rigid bondings (imposed temperatures or displacement components). The mathematical approach uses a variational method with a discretization on a grid of variable pitch which is either rectangular or triangular or both together. The number of meshes is not limited. The thermal problem can be solved in steady or transient state and the code may be used for independent thermal or elastic problems. This code has been written for a CD 6600 computer and is used extensively on behalf of several international organizations. (auth)

**21473** STRUCTURAL BEHAVIOR OF A SMALL-SCALE PRESTRESSED CONCRETE REACTOR VESSEL. Sozen, Mete A.; Paul, Stanley L. (Univ. of Illinois, Urbana). Nucl. Eng. Design, 8: 403-14(1968).

Discussion of the behavior and strength of prestressed concrete reactor vessels subjected to increasing internal gas pressure is presented. A description of the observed modes of failure in a series of tests of prestressed concrete reactor vessel models is included. Derivation and discussion of methods to calculate the ultimate structural capacities corresponding to the different modes of failure are presented. 5 references. (auth)

**21474** PREDVARITEL'NO NAPRYAZHENNYI ZHELEZOBETON V STROITEL'STVE YADERNYKH USTANOVOK. (Prestressed Ferro-Concrete for Construction of Nuclear Reactors). Komarovskii, A. N. Moscow, Atomizdat, 1968. 139p.

The book is a compilation of data published in USSR and abroad on the construction of reinforced concrete pressure vessels for high-pressure gas-cooled reactors. The data on reactor vessels from prestressed ferroconcrete, including the shape of the vessel, equipment, insulation, and tests, are described. Sim-

ulated ferroconcrete reactor vessels, cracks in the shieldings, effects of moisture on shielding, and radiation effects on physical properties of concrete are discussed. (R.V.J.)

## Cooling Systems

**21475** (BNWL–969) RADIOISOTOPE TRANSPORT AND DEPOSITION IN FLOWING SODIUM. Brehm, W. F.; Kovacevich, E. A.; Shannon, D. W. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Feb. 1969. Contract AT(45-1)-1830. 24p. (CONF-681106–2). Dep. CFSTI.

From Conference on Sodium Technology and Large Fast Reactor Design, Argonne, Ill.

Transport and deposition of radioisotopes released to flowing Na from corrosion of irradiated stainless steel has been studied. Quantitative measurements of deposition can be made with sensitive counting techniques. The results indicate that $^{51}Cr$ and $^{60}Co$ are transported primarily by isotopic exchange, and do not rapidly migrate to lower temperature regions of loop systems. However, $^{54}Mn$ is released in larger quantities to deposit throughout the test loops. Preferential deposition sites are immediately downstream from the source, at minimum temperature locations, and in oxygen cold traps. These results indicate $^{54}Mn$ is transported both by exchange and by solution-and-precipitation. Deposited $^{54}Mn$ migrated rapidly to the cold trap; deposited $^{51}Cr$ and $^{60}Co$ migrated slowly by exchange. 10 references. (auth)

**21476** HOT SPOT FACTOR IN THERMAL REACTOR CALCULATIONS. Kurjak, Pavle; Popovic, Aleksandar. Nukl. Energ., 5: No. 2, 17-20(1968). (In Serbo-Croatian).

The definition and division of the hot spot factor are given, and the calculation of the operating corrective factors elaborated. Under the assumption of the independence of parameters causing the corrective factors, and starting out from the assumption that all deviations are concentrated in one place, the general method of the calculation of conservative factors is provided. This method gives pesimistic evaluations of the corrective factors. The real values of the factors are smaller. The statistical method takes account of the probability of simultaneousness, and gives lower values for the corrective factors than the conservatively calculated. Starting out from an assumed risk the values are determined of the deviations which lower the value of the factors which in turn effects the large systems. 17 references. (auth)

**21477** ANALYSIS OF THE THERMAL STRESSES IN NUCLEAR VESSELS BY THE PHOTOELASTIC METHOD. Brcic, Vlatko (Univ., Belgrade); Pakvor, Aleksandar. Nukl. Energ., 5: No. 2, 1-6(1968). (In Serbo-Croatian).

The solution of differential equations whereby the state of stress in the thermal effects is being described is a very complex mathematical problem, even in very simple cases, in respect to the geometry of construction and the temperature field. Therefore, this problem is being approached experimentally. A brief survey of photo-thermo-elasticity, that is, the solution of the problem of thermal elasticity by way of optic-stress analysis (photoelasticity) is presented. A brief review follows of the contributions by various authors in the past years in that field, including the complex problem of photo-thermo-elastic similarity. Included is a review of the photoelastic investigation of the thermal stresses in two-dimensional models of a reactor vessel, accompanied by a description of the facility and the results obtained. (auth)

**21478** EVALUATING CRITICAL POWER IN ROD BUNDLE FUEL ELEMENTS COOLED WITH EVAPORATING WATER: PRESENT STATUS OF KNOWLEDGE. Gaspari, G. P.; Hassid, A.; Vanoli, G. (CISE, Milan). Termotecnica (Milan), 23: 43-54(Jan. 1969). (In Italian).

The phenomenological characteristics of heat transfer crisis in rod bundle power channels is presented, and, on the basis of the experiments carried out at CISE as well as the experimental data available in the literature, a detailed description of the main factors—thermohydraulic and geometrical—affecting critical power values (channel power at crisis onset) is given. A criterion is described which is being developed at CISE for critical power evaluation in rod bundles. From the comparison so far carried out with the experimental data relevant to different rod bundle types, the reliability of the criterion has been checked. (auth)

## Fuels

*Refer also to abstracts 19817, 19820, 20485, 20524, 21451, and 21537.*

**21479** (AECL–3252) PROCESS FOR FINISH MACHINING REACTOR PRESSURE TUBES. Melvin, J. G.; McEachern, A. D.; McManus, J. G. (Atomic Energy of Canada Ltd., Chalk River (Ontario). Chalk River Nuclear Labs.). Aug. 1967; Reprinted Jan. 1969. 27p. (CRNL–45). Dep. CFSTI. CAN $1.00.

Significant burnup gains in a CANDU reactor would result from closer manufacturing control of pressure tube wall thickness. A finish machining process which removes wall thickness variations greater than ±0.0005 in. has been demonstrated. Ultrasonic scanning of thickness is applied to the control of an electrochemical machining (ECM) system. (auth)

**21480** (EUR–4203) ERUPT: A TWO-DIMENSIONAL, TWO-ENERGY GROUP FUEL MANAGEMENT PROGRAMME FOR THE IBM-360 COMPUTER. Boettcher, W.; Decressin, A.; Lafontaine, F. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1968. 38p. Dep.

ERUPT is a program for survey calculations of fuel management on a two- dimensional model of a reactor core. The number of energy groups is two. Automatic computation of a variety of fuel management schemes is made possible, with and without fuel shuffling. The codification is in Fortran IV for the IBM-360/65 computer. (auth)

**21481** (EUR–4204) FUEL MANAGEMENTS FOR AN ORGEL PROTOTYPE ORIENTATION STUDY. Chambaud, B.; Charrault, J. C.; Decressin, A.; Tauch, P. (European Atomic Energy Community, Ispra (Italy). Joint Nuclear Research Center). 1968. 36p. Dep.

A comparison is made in order to assess the economical and technological potential of an ORGEL reactor operated with different fuel managements. All cases are normalized to plants of 250 MW(e) gross. Three managements are considered: on-power refuelling with axial shuffling (MA), on-power refuelling with radial shuffling (MR), and off-power refuelling with batch-wise shuffling (SR); moreover, the influence of variable fuel enrichment and radial reflector thickness is investigated. A first comparison in terms of fuel enrichment shows the predominant economic position of the MA management under the hypothesis of fuel burn-up being limited only by the reactivity potential. A second comparison envisages technological restrictions which limit the maximum local burn-up of the external rods in the fuel bundle. In this context a low burn-up region up to about 12,000 MWd/tU is clearly dominated by the MR management; in a transition zone up to about 20,000 MWd/tU the Mr and MA mangement are economically equivalent; above 20,000 MWd/tU maximum local burn-up the MA management is more attractive. (auth)

**21482** (EURFNR–610) THEORETICAL AND COMPUTER ANALYSIS ON THE BEHAVIOUR OF FAST REACTOR FUEL PINS AND RELATED PARTS OF THE CORE UNDER OPERATIONAL CONDITIONS. Karsten, G.; Kaempf, H.; Gerken, A. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Angewandte Reaktorphysik). Nov. 1968. 48p. (KFK–878; EUR–4158). Dep.

Work performed under United States–Euratom Fast Reactor Exchange Program.

A study of the maximum operation times of fuel pins was made by following the reference design study on the Sodium Cooled Fast Breeder Reactor Na-2. As the basis of this examination there was taken a defined three zone volume balance relating to the swelling of fuel volume and the consumption of void volume, given by the hot gap volume, the axial expansion and ratios of the pore volume. To calculate the maximum burnup with this model the radial temperature distribution had to be treated quantitatively. A new porosity relationship of the thermal conductivity was used. A two zone porosity model was applied for the characterization of the porosity migration in the plastic region connected with the central channel formation and a densification in the plastic region. The used zone swelling rates and applied availability factors were argued. The still unsolved fuel clad interaction problem was characterized and discussed. To initiate the quantitative treatment of the interaction problem a multiaxial stress and strain evaluation of the creeping sheath was carried out by an iterative method. 37 references. (auth)

**21483** (NIJS–P–228) FUEL FOR NUCLEAR POWER PLANT. Kolar, D.; Susnik, J. (Nuklearni Institut Jozef Stefan, Ljubljana (Yugoslavia)). Sept. 1968. 39p. (In Slovak). Dep.

Some technical and economic problems of nuclear fuel are discussed. The questions treated are cumulative and yearly consumptions of the fuel in HWR, fuel supply and inventory, and the influence of booster rods on the performance of the nuclear power plant. The Canadian natural uranium 340 MW(e) PHWR proposal served as a basis for calculations. The trends of the fuel element prices in the last years are presented and the future trends are estimated. The problem of the uranium ore supply in the world and particularly in Yugoslavia is briefly analyzed. Further, vari-

ous possibilities for long term fuel supply in the world market are described. The problem of fuel transport in the case of the simplest fuel cycle (no fuel reprocessing) is also treated. Finally, a brief estimate of the value of Pu, extracted from the spent fuel, is given. (auth)

**21484** (ORNL-4344, pp 200-10) MOLTEN-SALT IRRADIATION EXPERIMENTS. Bohlmann, E. G. (Oak Ridge National Lab., Tenn.).

FISSION PRODUCTS—concentrations in MSRE off-gas jumper line
GAMMA RADIATION—effects on sodium fluoroborate
MOLTEN SALT REACTOR EXPERIMENT—off-gas jumper line for, analysis of fission product concentrations in
REACTOR FUELS—radiation testing of molten-salt breeder reactor
REACTORS, MOLTEN-SALT—fuels for, irradiation testing of
SODIUM FLUOROBORATES—radiation effects on, measurement of $\gamma$ (D.C.C.)

**21485** (ORNL-TM-2477) BLANKET STUDY FOR A 1000 Mw(e) HTGR. Thomas, W. E. (Oak Ridge National Lab., Tenn.). Dec. 5, 1968. 32p. Dep. CFSTI.

The effects on conversion ratio and fuel-cycle cost resulting from the addition of a fertile ($^{232}$Th) blanket to a large HTGR have been studied. The blanket thickness, core power density, and ratio of core residence time to blanket residence time were varied. The use of a fuel which would release all the volatile fission products at a rate such that these nuclides would not contribute to the parasitic neutron losses was assumed. Results using the releasing fuel were compared with a conventional non-releasing fuel. Both a graphite moderator and a moderator consisting of a combination of graphite and BeO (C/BeO $\simeq$ 2.4) were considered in the study. Although the addition of a blanket improved the conversion ratio, its inclusion also increased the fuel-cycle costs. Two factors which contributed toward lowering the fuel-cycle cost (other conditions being equal) were exclusion of BeO from the moderator and increasing the power density from 7.0 w/cm$^3$ to 14.0 w/cm$^3$. Each contributed ~0.1 mill/kwhr(e) saving. Also a cost saving of ~0.2 mill/kwhr(e) was realized by using a fission-product-releasing fuel. However, with respect to the latter, fuel fabrication costs or increased capital costs for fission-product retention and removal were not considered. (auth)

**21486** (WCAP-3791-11) THE ANALYSIS OF MIXED CARBIDE REACTORS FOR THE AEC LMFBR TASK FORCE STUDIES. Final Report. (Westinghouse Electric Corp., Madison, Pa. Advanced Reactors Div.). Oct. 1967. Contract AT(30-1)-3791. 76p. Dep. CFSTI.

Two conceptual designs for 1000-MW(e), mixed PuC–UC reactors are presented; one is a Reference Reactor based on 1980 technology, and the other is an Advanced Reactor predicated on technology postulated for 1995. For each design the physics parameters required to calculate fuel costs over the life of the plant have been calculated, including the feed and discharge masses of the U and Pu isotopes for each cycle, from the first to equilibrium. The design characteristics are summarized. 12 references. (auth)

**21487** HEAT TRANSFER IN ROD BUNDLES. THE WINTER ANNUAL MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, NEW YORK, DECEMBER 3, 1968. New York, American Society of Mechanical Engineers, 1968. 174p. $8.50. (CONF-681209).

Topics discussed concerning heat transfer in rod bundles include: coolant mixing in rod bundles; pressure drop performance of rod bundles; theoretical aspects of heat transfer performance in clustered rod geometry; experimental heat transfer in rod bundles; and heat transfer to liquid metals flowing in-line through unbaffled rod bundles. Separate abstracts are included for each of the 5 papers presented. (D.C.C.)

*For abstracts of individual papers see: 21488–21492.*

**21488** COOLANT INTERCHANNEL MIXING IN REACTOR FUEL ROD BUNDLES: SINGLE-PHASE COOLANTS. Rogers, J. T. (Canadian General Electric Co., Ltd., Toronto); Todreas, N. E. pp 1-56 of Heat Transfer in Rod Bundles. New York, American Society of Mechanical Engineers, 1968.

From the Winter Annual Meeting of the American Society of Mechanical Engineers, New York. See CONF-681209.

Present analytic methods to predict coolant mixing in reactor fuel rod bundles are reviewed. The relevant experimental data which support the analytic methods are analyzed. The four mixing processes discussed include: turbulent interchange; diversion cross-flow; flow scattering; and flow sweeping. 75 references. (D.C.C.)

**21489** PRESSURE DROP PERFORMANCE OF A ROD BUNDLE. Tong, L. S. (Westinghouse Electric Corp., Pittsburgh). pp 57-69 of Heat Transfer in Rod Bundles. New York, American Society of Mechanical Engineers, 1968.

From the Winter Annual Meeting of the American Society of Mechanical Engineers, New York. See CONF-681209.

The pressure drop performance of a reactor fuel rod bundle is composed of three components: pressure loss along the bundle of bare rods; pressure loss at core entrance and exit; and pressure loss across the spacer grids or wires. The method of predicting the first component is similar to that for a flow inside a pipe by using the equivalent diameter concept. Data and correlations are presented for isothermal frictional pressure drop of a single phase flow inside a smooth or rough pipe, for surface heating effect on skin friction, and for flow at sudden contraction and expansion. 24 references. (auth)

**21490** SUMMARY OF THEORETICAL ASPECTS OF HEAT TRANSFER PERFORMANCE IN CLUSTERED ROD GEOMETRIES. Axford, Roy A. (Univ. of Illinois, Urbana. Los Alamos Scientific Lab., N. Mex.). pp 70-103 of Heat Transfer in Rod Bundles. New York, American Society of Mechanical Engineers, 1968.

From the Winter Annual Meeting of the American Society of Mechanical Engineers, New York. See CONF-681209.

Theoretical predictions of asymptotic Nusselt numbers and peripheral temperature and heat flux variations on the rod casing wall are summarized for rod cluster geometries for fully developed heat transfer with an axially uniform heat flux. The related hydrodynamic problems for fully developed laminar and turbulent flows are also considered. Single and multiregion models of rod clusters are presented. 23 references. (auth)

**21491** EXPERIMENTAL HEAT TRANSFER IN ROD BUNDLES. Sutherland, William A. (General Electric Co., Schenectady, N. Y.). pp 104-38 of Heat Transfer in Rod Bundles. New York, American Society of Mechanical Engineers, 1968.

From the Winter Annual Meeting of the American Society of Mechanical Engineers, New York. See CONF-681209.

The high degree of thermal performance for which nuclear reactors are designed requires a detailed knowledge of the heat transfer and fluid flow phenomena taking place within the core. This need has provided the impetus for the large number of analytical and experimental investigations of local heat transfer and fluid flow, as well as overall performance, in rod bundles. The results from a number of these investigations are presented. The application of the data to reactor core design is described. 39 references. (auth)

**21492** HEAT TRANSFER TO LIQUID METALS FLOWING IN-LINE THROUGH UNBAFFLED ROD BUNDLES: A REVIEW. Dwyer, O. E. (Brookhaven National Lab., Upton, N. Y.). pp 139-68 of Heat Transfer in Rod Bundles. New York, American Society of Mechanical Engineers, 1968.

From the Winter Annual Meeting of the American Society of Mechanical Engineers, New York. See CONF-681209.

The subject of heat transfer to liquid metals flowing longitudinally through unbaffled rod bundles is reviewed for conditions of equilateral triangular rod spacing, uniform (or approaching uniform) wall heat flux, and fully developed velocity and temperature profiles. Theoretical predictions and experimental results are compared for both close and wide spacings. Recent results on the following topics are also presented: circumferential variation of rod temperature; effect of rod displacement on its average heat transfer coefficient and on those of its six neighbors; effect of pitch: diameter ratio on the rod-average heat transfer coefficient; and the interrelated problems of wetting, oxides, and gas entrainment. 28 references. (auth)

**21493** DIGITAL COMPUTER APPLICATIONS FOR DATA PROCESSING OF NUCLEAR REACTOR AND POWER PLANTS. II. BURST CAN DETECTION ANALYSIS ON A HEAVY WATER MODERATED AND COOLED REACTOR. Grisollet, J.; Thegner, G. Energ. Nucl. (Paris), 10: 502-5(Dec. 1968). (In French).

A digital computer system for failed fuel element detection in heavy water reactors is described. A block diagram of the organization of the centralized surveillance system is included. The components of the data acquisition system are listed and described; data processing procedures are outlined. (M.L.S.)

**21494** STEAM COOLED EPITHERMAL OR FAST NUCLEAR REACTOR. Bogaardt, Maarten (to Reactor Centrum Nederland). U. S. Patent 3,425,904. Feb. 4, 1969. Filed Apr. 7, 1967.

A steam-cooled, epithermal or fast nuclear reactor is described in which the fuel elements contain particles of a resonance absorber for thermal or epithermal neutrons so that

accidental flooding of the reactor with water will not produce a super-critical condition. (Offic. Gaz.)

**21495** FACILITIES FOR IN-PILE TESTS OF CIRENE FUEL RODS. Scaroni, A. (CISE, Milan). Energ. Nucl. (Milan), 16: No. 4, 22-31(Apr. 1969).

The facilities for in-pile tests of fuel rods are described, which were used by CISE in the frame of a wide research program for the development of CIRENE reactors. A short description of the so called REBO plant is given, which is installed in the Avogadro reactor. The various equipment used for unloading and dismantling of the test-sections and for the post irradiation examinations are as well described. Finally, the results of operative experience are given, concerning more than one year in which the various equipments were operated in the frame of a research contract sponsored by the Italian Committee for Nuclear Energy. (auth)

**21496** RESEARCH PROGRAM ON PLUTONIUM RECYCLE UTILIZATION IN LIGHT WATER REACTORS UNDERTAKEN AT JPDR AND TCA OF JAERI. Suguri, Susumu; Matsuura, Shojiro (Japan Atomic Energy Research Inst., Tokyo). Nippon Genshiryoku Gakkaishi, 11: 150-7(1969). (In Japanese).

The recycled utilization of Pu produced in light water reactors is expected to become a prominent problem in the period from 1975 to 1990. While Pu utilization in light water reactors has been confirmed to be technically feasible in basic principle, practical application will still require prior solution of a number of problems. Of such problems, the most important in the domain related to reactor core characteristics include the accurate evaluation of the reaction rate in the fuel rod and of the power distribution in irregular lattices, as well as burnup systematics. Further detailed and accurate measurements and analyses must be performed on these problems through examination of burnup histories. A series of experimental and analytical studies using JPDR (Japan Power Demonstration Reactor) and TCA (Tank-type Critical Assembly) at the Japan Atomic Energy Research Institute is being planned for gaining information on the characteristics of $PuO_2$–$UO_2$ fuel assemblies and core, and as preliminary tests on fuels to precede their practical utilization in large power reactors. 7 references. (auth)

**21497** REACTOR CORE. Lass, James Lloyd; Mefford, Carl Rayford (to General Electric Co.). British Patent 1,147,145. Apr. 2, 1969. Priority date June 7, 1965, United States.

REACTOR FUEL ELEMENTS—assemblies of boiling reactor bundle-type, description of right angle four point leaf spring and stop spacers in multiple vertical
REACTORS, BOILING—core for, description of multiple vertical fuel bundles with right angle four point leaf spring and stop spacers in (D.C.C.)

**21498** REACTOR DEVICE. (to General Electric Co.). British Patent 1,147,144. Apr. 2, 1969. Priority date June 7, 1965, United States.

REACTOR FUEL ELEMENTS—spacers for boiling reactor bundle-type, description of right angle four point leaf spring and stop
REACTORS, BOILING—fuel element spacers for, description of right angle four point leaf spring and stop (D.C.C.)

## Auxiliary and Emergency Systems

**21499** (BAW-3647-10) PHYSICS VERIFICATION PROGRAM. PART III. Quarterly Technical Report, July–September 1968. Baldwin, M. N.; Stern, M. E. (Babcock and Wilcox Co., Lynchburg, Va. Critical Experiment Lab.). Feb. 1969. Contract AT(30-1)-3647. 34p. Dep. CFSTI.

The experiments to investigate the response of an incore all-solid self-powered Rh-wire neutron flux monitor at temperatures approaching those of an operating pressurized-water power reactor are described. The experiments were performed inside a high-temperature test vessel located adjacent the Lynchburg Test Reactor. Measurements were made in borated and nonborated water and in a subcritical fuel lattice. Activation measurements are presented. (D.C.C.)

**21500** ISOLATION VALVES CONTRIBUTE TO BWR SAFETY. Power, 113: No. 4, 85(Apr. 1969).

A description of $\gamma$-pattern globe type steam-line isolation valves for boiling power reactors is presented. The effects on reactor operation safety are described. (D.C.C.)

## Operation and Economics

**21501** (ORNL-4344, pp 1-52) MOLTEN SALT REACTOR EXPERIMENT. Haubenreich, P. N. (Oak Ridge National Lab., Tenn.).

CERIUM ISOTOPES Ce-141—deposition in MSRE fuel and heat transfer systems
CESIUM ISOTOPES Cs-137—deposition in MSRE fuel and heat transfer systems
FISSION PRODUCTS—deposition in MSRE fuel and heat transfer systems, comparison of
FLANGES—thermal-cycle testing of freeze-type, description of MSRE
IODINE ISOTOPES I-131—deposition in MSRE fuel and heat transfer systems
IODINE ISOTOPES I-132—deposition in MSRE fuel and heat transfer systems
LANTHANUM ISOTOPES La-140—deposition in MSRE fuel and heat transfer systems
MOLTEN SALT REACTOR EXPERIMENT—operations during March to August 1968
—maintenance during March to August 1968
—fuel salt fluorination data for
—fission product deposition in fuel and heat transfer systems of
—stability of uranium 233-fueled, calculation of
MOLYBDENUM ISOTOPES Mo-99—deposition in MSRE fuel and heat transfer systems
NIOBIUM ISOTOPES Nb-95—deposition in MSRE fuel and heat transfer systems
RADIATION MONITORING—levels in MSRE during March to August 1968
REACTIVITY—power tests for MSRE, effects of power level on frequency response in
REACTOR FUELS—fluorination data for MSRE fuel salt
RUTHENIUM ISOTOPES Ru-103—deposition in MSRE fuel and heat transfer systems
RUTHENIUM ISOTOPES Ru-106—deposition in MSRE fuel and heat transfer systems
TELLURIUM ISOTOPES Te-132—deposition in MSRE fuel and heat transfer systems
URANIUM FLUORIDES $UF_6$—recovery of MSRE fuel salt, performance of absorbers for (D.C.C.)

**21502** SMALL AND MEDIUM-SIZE POWER REACTORS. Kruck, P. H.; Ristic, M. D. (IAEA, Vienna). Nucl. Eng. Int., 14: 209-12(Mar. 1969).

The continued need for small and medium power plants in underdeveloped countries is discussed. Factors which favor smaller units are outlined. Comparison of possible reactor types suggests that HWRs have the best potential. The economic competitiveness of nuclear power with oil-fired plants is shown to depend upon plant size and local fuel oil prices, but with future technical and economic improvements smaller plants could become more competitive. (UK)

**21503** IS THE AVAILABLE GROWTH AND LIFETIME OF NUCLEAR POWER PLANTS OVEREMPHASIZED TODAY. Schenk, H. (Kernkraftwerk, Obrigheim, Ger.). Atomwirt., Atomtech., 14: 21-3(Jan. 1969). (In German).

Availability of nuclear power plants is discussed; availability is tabulated as a function of years of operation. Outages are tabulated for Shippingport, Dresden 1, Yankee, Big Rock Point, and Humboldt Bay; reasons for outages are shown; effects of outages are considered. Conclusions are drawn relative to the plant lifetime, availability, and use. (M.L.S.)

## Safety and Siting

**21504** (IDO-17275) HYDRAX: A FORTRAN PROGRAM TO CALCULATE THE ENERGY RELEASE DURING A REACTIVITY ACCIDENT IN A WATER-MODERATED REACTOR. Hagen, R. N. (Phillips Petroleum Co., Idaho Falls, Idaho. Atomic Energy Div.). Dec. 1968. Contract AT(10-1)-205. 235p. Dep. CFSTI.

The HYDRAX computer program was developed to predict the fission energy release during a potentially destructive reactivity accident in a water-moderated reactor. HYDRAX solves the space-independent reactor kinetics equations together with coupled one-dimensional fuel thermal balance and moderator thermal and hydrodynamic balance equations. Various reactivity feedback relationships in turn couple the fuel and moderator equations to the kinetics equations. A simple fuel-element-failure model approximates the effect of hot fuel particles dispersing into the moderator. A main feature of the code is the compressible hydrodynamic model of the water moderator incorporating a tabular,

multiphase equation-of-state based on the 1967 ASME Steam Tables. (auth)

**21505** (IRS-I-34(1968)) FAILURE RATES OF PRESSURE VESSELS. PART I. EVALUATION OF VdTUEV STATISTICS. Slopianka, G.; Mieze, G. (Technischer Ueberwachungs-Verein e. V., Cologne (West Germany). Institut fuer Reaktorsicherheit). [1968]. 43p. Dep.

To obtain some indication of the failure behavior of nuclear pressure vessels, the information compiled by the Technischen Uberwachungs-Vereine (TUV) since 1952 on the failure of non-nuclear pressure vessels and boilers was evaluated statistically. The results of the evaluation are presented, and their possible application to reactor pressure vessels is discussed. (H.D.R.)

**21506** HTGR CONCERN CLARIFIED. Kaplan, S. I. (Oak Ridge National Lab., Tenn.). Nucl. Appl., 6: 265(Apr. 1969).

Comments concerning the capability of a high temperature gas-cooled reactor for producing potentially dangerous amounts of $H_2$ and CO from water vapor in the coolant conclude the safety consequences of this occurrence to be remote. (H.D.R.)

### Power Conversion Systems

**21507** STRAIGHT STEAM CYCLE FOR GCFBR. Streeton, D. F. (Suiselectra AG, Basel); Lys, L. A. Nucl. Eng. Int., 14: 213- (Mar. 1969).

Considerations related to steam cycle selection for a gas-cooled FBR are discussed with particular reference to the performance of a straight cycle. This cycle is attractive and could find widespread application, especially where it is desirable to reduce steam generator dimensions. (auth)

## Research and Test Reactors

*Refer also to abstracts 19918, 19982, 20038, 21447, 21464, 21495, and 21496.*

**21508** (AEEW-R-499) ANALYSIS OF REACTIVITY MEASUREMENTS IN HECTOR ON SINGLE PLUTONIUM-URANIUM OXIDE CLUSTERS. Bannerman, R. C. (Atomic Energy Establishment, Winfrith (England)). Aug. 1968. 117p. Dep. CFSTI. UK 16s.

A series of reactivity perturbation measurements was carried out in the HECTOR reactor on single $PuO_2-UO_2$ clusters. These clusters were 14 in. long, with a geometry similar to that used in the Windscale A.G.R., and contained up to 2% Pu with a $^{240}Pu$ content from 3% to 26%. These Pu contents cover the range encountered both in burn-up and in possible Pu enrichment of an A.G.R. A method of analyzing the measurements was developed, which uses as a starting point reaction rates produced by any suitable single-cell lattice code. A comparison between the measured and calculated reactivity perturbations for a given single Pu-bearing cluster then provides a measure of the accuracy of k-infinity calculated by that code for a complete lattice containing that particular fuel. The experimental results were analyzed using reaction rates obtained from the ARGOSY 4 code. Good agreement was found between calculated and measured reactivity perturbations for all samples. Errors, in terms of k-infinity for each sample lattice, were typically ±0.5% for samples containing 0.25% and 0.4% Pu, and ±0.9% for samples containing 2% Pu. The effect of changing the $^{240}Pu$ content of a sample was predicted to within 5% of the change. Temperature coefficients over the range 22°C to 427°C were correctly predicted within 0.001 to 0.002% reactivity /°C. These results were found to be independent, within wide limits, of the reactor environment lattice in which the reactivity perturbation measurements were made. It is possible, therefore, to carry out useful measurements on Pu-bearing fuel in a lattice loaded with U fuel, with a considerable saving in the amount of the Pu-bearing fuel required. 33 references. (auth) (UK)

**21509** (APDA-208) COMPARATIVE HYPOTHETICAL ACCIDENT ANALYSIS FOR FOUR INTERIM CORE DESIGNS FOR THE FAST TEST REACTOR. Ball, G. L.; Klickman, A. E. (Atomic Power Development Associates, Inc., Detroit, Mich.). Jan. 1968. Contract AT(11-1)-865. 51p. Dep. CFSTI.

The maximum energy release values are compared for a complete meltdown collapse in each of four core types tentatively considered for the Fast Test Reactor. The core types calculated were a 600-liter $PuO_2$-SS cermet core, an 800-liter mixed-oxide core, a 600-liter mixed-carbide core, and a 600-liter metal alloy core. The energy release calculations utilized simplified spherical geometries and assumed uniform Na-free core compositions. The initial ramp rates were determined by assuming initial instantaneous core meltdown and gravitational collapse into more reactive configurations. The resulting reactivity transients were calculationally terminated by fuel expansion in response to large pressure gradients established in the core with the vaporization of fuel. The pressure-energy relationships of the fuels, i.e., the equations of state, were estimated by applying the method of corresponding states to extrapolate available high pressure data for light compounds to the heavy compounds of fast reactor fuels. Doppler coefficients were taken into account, as were delayed neutron data. For each core concept the fraction of the total energy release available for destructive work upon reactor structures and containment was calculated, assuming an adiabatic expansion of the fuel vapor upon termination of the reactivity transient. An identification was made of the fundamental attributes of each core concept studied which primarily determined its maximum accident energy release value. 19 references. (auth)

**21510** (BNL-13208) BROOKHAVEN PULSED FAST RESEARCH REACTOR. Hendrie, J. M.; Hoffman, K. C.; Kouts, H. J. C.; Parsick, R. J.; Phelps, J. P.; Price, G. A.; Reich, M.; Takahashi, H.; Windsor, H. H. (Brookhaven National Lab., Upton, N. Y.). Jan. 1969. 69p. (CONF-690102-2). Dep. CFSTI.

From Fast Burst Reactor National Topical Meeting, Albuquerque, N. Mex.

The repetitively pulsed fast reactor is of interest as a high intensity source for neutron beam experiments. The design characteristics of a conceptual pulsed reactor operative at an average power of 30 MW are discussed. The peak power during a pulse is about 4,700 MW and the pulse width at half-maximum power is 90 microseconds. The reactivity is varied by means of reflector sections carried past a bare face of the core on high speed rotors. A two-rotor system is preferred in order to provide for variation of the repetition rate between 20 and 60 pulses/sec. The performance of the system described is limited by the ability of the fuel to withstand the cyclic thermal and inertial stresses caused by power pulsing. The high cycle fatigue strength of a cermet fuel with a Mo matrix was determined in the unirradiated condition and these data were used as the basis for the core design. Development and test work on this fuel and on other potential pulsed reactor fuels such as Nb-U-Zr ternary alloys and a Th-U dispersion are outlined. A series of critical experiments and beam source optimization studies were performed in support of the design effort and these are described. (auth)

**21511** (BNWL-961) FISSION PRODUCT INVENTORY AND DECAY HEAT ASSOCIATED WITH FTR FUEL. Bunch, W. L.; O'Dell, L. D. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Feb. 1969. Contract AT(45-1)-1830. 76p. Dep. CFSTI.

The fission product inventory and the decay heat associated with driver fuel irradiated to goal exposure (45,000 MWd per metric ton) in the Fast Test Reactor is presented, based on calculations using the computer code RIBD with a nuclear data library prepared for the FTR environment. Curie inventories as a function of decay time are given for each of about 350 isotopes or isomeric states generated by the fast-neutron induced fission of either $^{239}Pu$ or $^{238}U$, by down-chain decay, or by subsequent neutron capture. Beta, gamma, and total decay power are given in percent of operating power for decay times from 1 sec to about 10 years. Uncertainty in the decay heat calculations, based on propagation of the uncertainties associated with input nuclear data, is estimated. The uncertainty is calculated to be less than ±10% for the first 10 days, and less than ±20% over a 10-yr decay period. 29 references. (auth)

**21512** (CEA-CONF-1247) RAPSODIE'S FIRST YEAR OF OPERATION. Gajac, G.; Ratier, J. L.; Reboul, M.; Reynes, L.; Valantin, M. A. (Commissariat a l'Energie Atomique, Cadarache (France). Centre d'Etudes Nucleaires). [1969]. 32p. (CONF-681106-14). Dep.

From Conference on Sodium Technology and Large Fast Reactor Design, Argonne, Ill.

The fuel of Rapsodie's first core achieved a burn-up of 40 457 MWd/t on September 25, 1968. This burn-up corresponded to a total of 6183 MW days of thermal energy, or 286 equivalent days at full power. Since the beginning of routine operation in August 1967 the reactor behaved perfectly, with an availability of 91%. The fuel irradiation performance has been very good, since releases of gaseous fission products have occurred only rarely. These releases have by no means interfered with normal reactor operation. (auth)

**21513** (GA-8767) FAST CRITICAL EXPERIMENTS IN SUPPORT OF THERMIONIC REACTOR PHYSICS. Cohen, S. C.;

Moore, R. A.; Russell, J. L. Jr.; Sargis, D. A.; Sharp, R. (Gulf General Atomic, Inc., San Diego, Calif.). Aug. 26, 1968. Contract AT(04-3)-167. 22p. (CONF-681035-1). Dep. CFSTI.

From IEEE Thermionic Conversion Specialist Conference, Framingham, Mass.

The objective of the Thermionic Critical Experiment is to compare integral neutronic data from a series of critical assemblies with detailed neutronic calculations and to check analytical methods and cross section data used in the core design of thermionic space power reactors. An orderly progression of assemblies ranging from the very simple in composition and configuration to actual zero-power mockups of thermionic reactors is planned. The early experiments will feature bare, homogeneous assemblies which will provide clean integral data concerning the cross sections of thermionic materials. The integral data will be augmented by differential neutron spectrum measurements by the pulsed source, time-of-flight method. Assembly No. 1, a bare, neutronically homogeneous mixture of fully enriched uranium and polyethylene, was taken critical on May 10, 1968. The composition was chosen to provide a reasonably clean neutronic simulation of the neutron spectrum for a thermionic reactor core reflected with beryllium oxide. Measurements completed to date include critical mass, subcritical neutron spectrum, and central reactivity worths of thermionic reactor materials. The results of these initial experiments are compared with analysis. 12 references. (auth)

**21514** (GEMP-402(Add.2)) NASA CAVITY REACTOR CRITICAL EXPERIMENT MODULAR CORE. Addendum No. 2 to Final Safety Analysis Report. Briscoe, G. J.; Lofthouse, J. H.; O'Brien, R. B. (General Electric Co., Idaho Falls, Idaho. Missile and Space Div.). Mar. 14, 1969. Contract AT(40-1)-2847. 19p. Dep. CFSTI.

A proposed short series of tests on the two modular cores, which involve a relatively major change in the physical configuration of the cavity reactor, are described. Due to this change, the probability of $D_2O$ leakage may be increased to some extent, and the flooding characteristics of the core are considerably altered. Nevertheless, it is believed that core flooding continues to constitute a very low risk, in terms its potential for causing a hazardous nuclear accident. The reference accident used for the evaluation of radiological hazards in the original cavity reactor safety analysis, is still generally applicable. However, due to detail differences in the fuel loading and fuel support structure, as well as improved calculational techniques, the reference excursion was re-analyzed. As a result, the reference excursion, and consequent radiological hazards, were predicted to be somewhat less severe than those presented in the original safety report. It is concluded that operation of the cavity reactor modular core experiments can be carried out safely, as planned, and that the required alterations in the experimental assembly represent an insignificant change from the standpoint of safety. (auth)

**21515** (GEMP-663) NUCLEAR TEST GAUGE SAFETY ANALYSIS REPORT. Briscoe, G. J.; Lofthouse, J. H.; O'Brien, R. B. (General Electric Co., Idaho Falls, Idaho. Missile and Space Div.). Feb. 21, 1969. Contract AT(40-1)-2847. 67p. Dep. CFSTI.

The Nuclear Test Gage (NTG) is a subcritical nuclear assembly, fueled with enriched uranium foils and moderated and reflected by Plexiglas, which is used to measure the relative nuclear characteristics of reactor materials. The NTG was constructed and operated for eight years at the Evendale, Ohio, plant which is operated for the AEC by General Electric Company, Nuclear Systems Programs. In 1966, it was shipped, fully fueled, to the GE-NSP Idaho Test Station where it is now set up for evaluation and use. Although the system is to be maintained in the subcritical condition, it is provided with essentially the same safeguards and is to be operated under the same administrative controls as are critical experiment reactors. Therefore, the probability of a nuclear excursion is very low. Nevertheless, a series of postulated nuclear transients has been analyzed. The radiological hazards associated with the worst of these are minimal, and it is concluded that the proposed operation of the NTG constitutes a negligible public risk. 9 references. (auth)

**21516** (IDO-17281) REACTIVITY ACCIDENT TEST RESULTS AND ANALYSES FOR THE SPERT III E-CORE: A SMALL, OXIDE-FUELED, PRESSURIZED-WATER REACTOR. McCardell, R. K.; Herborn, D. I.; Houghtaling, J. E. (Phillips Petroleum Co., Idaho Falls, Idaho. Atomic Energy Div.). Mar. 1969. Contract AT(10-1)-205. 185p. Dep. CFSTI.

A program of reactivity accident tests has been performed with the Spert III E-core—a small, oxide-fueled, pressurized-water reactor (PWR), which except for size is generally characteristic of an unborated, commercial PWR with essentially no fission product inventory in the core. With this core, 80 nondamaging power excursions were initiated from typical PWR operating conditions, viz, cold-startup, hot-startup, hot-standby, and operating-power initial conditions. The excursions resulted from rapid reactivity insertions ranging from 0.5 to 1.3$. The data obtained provide the only known experimental reactivity accident results for low-enriched oxide cores at initial conditions other than cold-startup. The cold-startup power excursions were essentially limited by Doppler broadening of $^{238}U$ resonance absorption cross sections, which provided the majority of the total reactivity compensation. For the other test conditions, reactivity feedback resulting from prompt moderator heating, caused by slowing down of fast neutrons and absorption of prompt gamma rays, became a significant contributor to the total reactivity feedback. The IREKIN and PARET computer codes were evaluated using the experimental data. The IREKIN code, which considers only reactivity feedback from Doppler broadening, provided satisfactory predictions for only the cold-startup tests. The comprehensive PARET code yielded excellent predictions for all accident conditions tested. (auth)

**21517** (NYO-841-17) APPLICATION OF A PEBBLE BED HEAT-SINK TO THE FAST FLUX TEST FACILITY CLEANUP SYSTEM. Preliminary Report. Bulba, E.; Underhill, D. (Harvard Univ., Boston, Mass. Harvard Air Cleaning Lab.). Mar. 1969. 25p. Dep. CFSTI.

Mathematical equations have been developed for computing gas temperatures within a ventilation cleanup system following the accidental release and burning of Na coolant within the containment volume of the Fast Flux Test Facility. The derivation is based on the assumption that the Facility is equipped with a cleanup system consisting of a pebble bed heat-sink and bag filters. The approach is unique in that it permits computation of heat transfer under conditions of a variable inlet gas temperature to the bed. One difficulty in the analysis is that under operating conditions it is anticipated that major amounts of Na fume will deposit within the bed. 9 references. (auth)

**21518** (ORNL-TM-2504) BULK SHIELDING FACILITY QUARTERLY REPORT, OCTOBER-DECEMBER OF 1968. Tabor, W. H. (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 31p. Dep. CFSTI.

Operations for the BSR during October to December 1968 are described. Scheduled and unscheduled shutdowns during the quarter are listed and analyzed. Required maintenance is described. The fuel inventory changes are presented. Experimental facility assignments are listed. Shim rod calibration curves are presented. (D.C.C.)

**21519** (ORNL-TM-2537) OAK RIDGE RESEARCH REACTOR QUARTERLY REPORT, OCTOBER-DECEMBER OF 1968. Tabor, W. H.; Hurt III, S. S. (Oak Ridge National Lab., Tenn.). Apr. 1969. Contract W-7405-eng-26. 36p. Dep. CFSTI.

Operations for the ORR during October to December 1968 are described. Scheduled and unscheduled shutdowns and power reductions during the quarter are listed and analyzed. Required maintenance is described. The fuel inventory changes are presented. Experimental facility assignments are listed. (D.C.C.)

**21520** (ORNL-TM-2541) HFIRHY: A COMPUTER PROGRAM FOR CALCULATION OF FLOW DISTRIBUTION AND PRESSURE DROP IN THE HFIR CORE. Haack, L. A. (Oak Ridge National Lab., Tenn.). Mar. 14, 1969. Contract W-7405-eng-26. 17p. Dep. CFSTI.

A computer program, HFIRHY, has been written which calculates flow rates through the major parallel flow paths of the HFIR core and the pressure drop across the fuel element. The program is simply a computer version of the manual method outlined previously and adapted for use at HFIR. Written in FORTRAN IV for use on the online CDC-1700 computer, the program uses 16 inputs (most of which are pressure readings across either a venturi meter, or orifices, or between various parts of the reactor pressure vessel). The inputs are combined with appropriate flow-$\Delta p$ correlations which were obtained out-of-pile during development of the various reactor components several years ago. At present, all readings are taken by an operator and later entered on a teletype for execution of the program. However, with modification to some of the instrumentation, the CDC-1700 could read all the necessary data (the computer already continuously monitors many of the reactor parameters required for the program) and then execute the program with no need to enter manually the required data. (auth)

**21521** (SRRC-28/68(Pt.2)) UPGRADING POWER OF THE SCOTTISH UNIVERSITIES RESEARCH REACTOR, PART 2. PROPOSED SCHEME FOR INCREASING REACTOR POWER TO 300 kW THERMAL. Riley, J. A. (Scottish Research Reactor Centre, East Kilbride (Scotland)). 1968. 41p. Dep.

A scheme is presented that should enable the maximum permissible operating power of the Scottish Universities Research Reactor to be raised to 300 kW(t) while ensuring that boiling does not occur in the reactor core. The scheme entails installing a forced draught cooling tower in the secondary circuit, increasing the primary circuit water flow rate to 55.2 gpm, and increasing the secondary circuit water flow rate to 108 gpm. New primary and secondary circuit pumps will be required to attain the increased flow rates. (auth)

**21522** CONVERTER SD-4 DESIGN AND SUMMARY OF TEST RESULTS. Howard, R. C.; Dunlay, J. B. (Thermo Electron Corp., Waltham, Mass.). Energy Convers., 9: 25-30(Mar. 1969).

An in-pile test at the BRR reactor for a cylindrical thermionic converter with a Re emitter fueled with a cermet of $UO_2$–W is described. The external environment of the converter was a static vacuum formed by an initial pump-out and seal-off of a stainless steel housing. The test operated in-pile for 8125 hr over a period of about 2 yr, and more than 80 cycles between shutdown and full power occurred during this period. The average electrode power density throughout the test lifetime was 7.8 W/cm$^2$. For fixed reference levels of reactor power, Cs pressure and collector temperature, the diode performance was stable throughout the life of the test. The test was terminated when difficulties occurred in auxiliary heaters and coolant systems which caused a loss of control of the cesium reservoir temperature. The design of the converter and the test capsule is described, together with the test history and a summary of the test data. (auth) (UK)

**21523** DOSE-EQUIVALENT RATES OF NEUTRONS AND GAMMA RAYS IN THE ENVIRONMENT OF THE WWR-SM REACTOR. Makra, Zsigmond; Toth, Mihaly. KFKI (Kozp. Fiz. Kut. Intez.) Kozlem., 16: 381-97(1968). (In Hungarian).

Results of the determination of dose-rate-equivalents for thermal, intermediate and fast neutrons as well as the $\gamma$ rays in the environment of the biological shield after the modification of the Hungarian WWR–S reactor, WWR–SM, are reported. In spite of the increased power level, the dose equivalent rates measured in the top area of the reactor were found to be substantially lower than before, owing to the modifications in the top shield. The non-modified annular shield is still satisfactory. The newly built-in shutters of the horizontal channels, water tank-iron disc combination, improved the dose attenuation as compared with the formerly used mechanical shutters. 8 references. (auth)

**21524** DIFFERENCE OF THE STEADY AND DECAYING STATE SPECTRA IN MULTIPLYING ASSEMBLY. Aizawa, Otohiko; Yamamuro, Nobuhiro (Tokyo Inst. of Tech.). Bull. Tokyo Inst. Technol. (Engl. Ed.), No. 83, 115-21(Nov. 1968).

Cd- and Gd-ratios of the steady and the decaying state neutron flux have been measured in multiplying assemblies. These ratios have shown the obvious difference between the steady and the decaying state. The present experimental results are in good agreement with the calculated spectral indices using the Nelkin kernel over the wide range of the fuel to moderator atomic ratios. (auth) (NSA of Japan)

**21525** CONCEPTS AND GENERAL DESCRIPTION OF A FAST EXPERIMENTAL REACTOR CORAL-I. Verdaguer Hernandez, F.; Gutierrez Bernal, R. Energ. Nucl. (Madrid), 12: 320-36(July-Aug. 1968). (In Spanish).

The history of the development of fast reactors is summarized. A general description of the Spanish CORAL-I fast research reactor is given; general characteristics are tabulated. Cross sectional views of the moveable reflector, central core region, and shield are shown. Nuclear instrumentation and safety logic are described briefly. Reactivity worths of control rods and reactivity coefficients are tabulated. 37 references. (M.L.S.)

**21526** BIOLOGICAL PROTECTION FOR REACTOR CORAL-I. Azcue, Joaquin; Rovira, Amadeo (Junta de Energia Nuclear, Madrid). Energ. Nucl. (Madrid), 12: 395-403(July-Aug. 1968). (In Spanish).

The Coral-I core configuration and the concrete biological shielding are described. A maximum of $10^{17}$ fissions/sec is estimated for potential accidental excursions. Calculations indicate the radiation dose at the exterior of the shield from the maximum excursion to be less than 25 Rem/sec for 150 cm of concrete. (H.D.R.)

**21527** ELECTROMECHANICAL DEVICES FOR SAFETY AND CONTROL OF FAST REACTOR CORAL-I. Tanarro Sanz, Antonio (Junta de Energia Nuclear, Madrid). Energ. Nucl. (Madrid), 12: 385-94(July-Aug. 1968). (In Spanish).

Safety valves and safety rods for the Spanish CORAL-I fast research reactor are described. The safety rod positioning devices and control rod drive mechanisms are discussed. The neutron source and source drive are described. (M.L.S.)

**21528** ELECTRONICS AND LOGIC OF SAFETY INSTRUMENTATION FOR THE FAST REACTOR CORAL-I. Goni, Javier; de Carlos, Jose E.; Tanarro, Agustin (Junta de Energia Nuclear, Madrid). Energ. Nucl. (Madrid), 12: 365-83(July-Aug. 1968). (In Spanish).

The control systems and instrumentation for the Spanish fast CORAL-I are described. The function of the startup, linear, and log channels is discussed; a schematic is included. The control console is described. Electronic and operational logic is detailed; circuit diagrams illustrating logic operations are shown. The reactor protective system is described; logic equations and block diagrams are included. 12 references. (M.L.S.)

**21529** THEORETICAL CALCULATIONS FOR THE PROJECT CORAL-I. PART II. THE MONTE-CARLO METHOD AND APPLICATION TO THE REACTOR CORAL-I. de Francisco, J. L. (Junta de Energia Nuclear, Madrid). Energ. Nucl. (Madrid), 12: 346-53(July-Aug. 1968). (In Spanish).

Application of Monte Carlo methods to physics calculations for the Spanish fast research reactor, CORAL-I is described. Critical mass and $k_{eff}$ calculations are discussed; reactivity worths of the test facilities are given. Reactor control and safety are detailed. In-core and in-reflector neutron energy distributions are shown; radial and axial flux profiles are included. (M.L.S.)

**21530** THEORETICAL CALCULATIONS FOR THE PROJECT CORAL-I. PART I. THE J.E.N. MODEL OF CALCULATION FOR FAST REACTORS AND APPLICATION TO THE CORAL-I. Caro, R. (Junta de Energia Nuclear, Madrid). Energ. Nucl. (Madrid), 12: 339-45(July-Aug. 1968). (In Spanish).

The mathematical model used for the CORAL-I fast research reactor calculations is described. The JEN computer program for fast reactor kinetics calculations is discussed; equations which were programmed are given. Reactivity calculations are tabulated for enriched and dilute systems; comparisons of neutron spectra for dilute assemblies are tabulated using the JEN and DS-8 codes. (M.L.S.)

**21531** KINETICS OF CORAL-I. Mayquez, Eduardo Rodriquez (Junta de Energia Nuclear, Madrid). Energ. Nucl. (Madrid), 12: 355-62(July-Aug. 1968). (In Spanish).

REACTORS, RESEARCH — control of Spanish fast CORAL-I, effects of delayed neutrons on
—kinetic parameters for Spanish fast CORAL-I (M.L.S.)

**21532** EXPERIMENTAL STUDIES ON 20 PERCENT ENRICHED URANIUM–LIGHT WATER ASSEMBLY (TITAN). 2. NEUTRON FLUX DISTRIBUTION IN SLAB FUEL ELEMENTS. Okubo, M; Miyawaki, Y. (Tokyo Inst. of Tech.). Bull. Tokyo Inst. Technol. (Engl. Ed.), No. 83, 7-21(Mar. 1968).

The fine structure of the thermal neutron flux distribution in a slab fuel element, and the ripple of the thermal neutron flux distribution in the moderator between the fuel plates were measured by the In and Dy foil activation technique. The Nuclear Assembly of Tokyo Institute of Technology, and a small aluminium tank were used in the experiment. From the measurement of the fine structure of the thermal neutron flux distribution in a fuel element, the neutron flux peaking in the water trap between the fuel elements was observed. The results of the measurement of the ripple of the thermal neutron flux distribution were compared with the results of the calculation based on the collision probability method. The disadvantage factors were obtained from the results of the calculation. They were 1.056 for 7 plates/box, 1.051 for 10 plates/box, and 1.036 for 19 plates/box, respectively. The calculation was made by the use of the neutron cross section averaged over Wigner and Wilkins spectrum. The results agreed well with the experiment. (auth) (NSA of Japan)

## Rocket and Space Reactors

*Refer also to abstract 20484.*

**21533** (AI-AEC-12779) S8DR ACTUATOR. Second Interim Report. Donelan, L. E. (Atomics International, Canoga Park, Calif.). Mar. 1, 1969. Contract AT(04-3)-701. 30p. Dep. CFSTI.

High-temperature, radiation-resistant, rotary actuators have been developed for use in the control system of SNAP reactors. These actuators are electromagnetic, variable-reluctance, stepping devices with integral, spring-loaded brakes. Five actuators were built, and four of these have been tested successfully to date to the environmental and performance requirements of the

SNAP 8 Development Reactor (S8DR) Program. These tests are still being conducted. The five actuators were modifications of the originally designed units. These modifications were made as a result of design-margin tests which were conducted at 1125°F (100°F above maximum design temperature). The results of the design-margin tests, the modifications that were made in the original design, and the proof tests that were conducted on the modified design are presented. The results of the tests, to date, indicate that the modified actuators should meet all requirements for the S8DR Program. (auth)

**21534** (NP-17783) A SAFETY EVALUATION OF SNAP REACTOR SYSTEMS. Report of the Committee on The Nuclear Space Program. (Atomic Industrial Forum, Inc., New York). Aug. 1968. 124p.

An evaluation of the nuclear safety aspects of aerospace missions utilizing reactor systems for electric power is presented. Topics discussed include: reactor systems; influence of mission characteristics on SNAP reactor safety; description of potential accidents and environments; criticality considerations; post-operational reactor disposal; radiological hazards; and quantitative analysis of hazards. 55 references. (D.C.C.)

**21535** UNITED STATES PROGRESS ON NUCLEAR PROPULSION FOR ROCKETS. Finger, H. B. (Atomic Energy Commission, Washington, D. C.). pp 193-208 of Problems of Propulsion and Re-entry. Lunc, Michal (ed.). New York, Gordon and Breach, Inc., 1967.

From 17th International Astronautical Congress, Madrid. See CONF-661051.

A review of the U. S. nuclear rocket propulsion development program is presented. Descriptions and tests results for the NERVA, KIWI, and NRX reactors are also presented. Performance data for the Engine System Test operation are included. Proposed payload considerations for flyby missions, lunar direct landing missions, and unmanned solar system missions are presented. (D.C.C.)

**21536** COMMON NUCLEAR MODULE FOR PLANETARY EXPLORATION. Dollard, J. F. (Boeing Co., Huntsville, Ala.). J. Spacecraft Rockets, 6: 136-42(Feb. 1969).

A new concept using nuclear propulsion modules to perform a wide spectrum of manned planetary missions is described. The ability of this system to perform Mars and Venus missions in the 1980 to 1990 period using various numbers of these identical modules is presented. Considerable payload, mission, and program flexibility results. Consideration of Earth-launch-facility height limitations, two-stage Saturn V uprated capability, Earth-launch-vehicle cost effectiveness, and module mass fraction results in a baseline module of 360,000-lb propellant capacity. However, module sizes between 300,000- and 380,000-lb propellant capacity are near optimum. The baseline module requires a Saturn V with four, four-segment, 156-in.-diam, strap-on solid rockets and uprated F-1 and J-2 engines with a capability of delivering 560,000 lb to a 100-naut-mile earth orbit. Saturn V uprating steps covering this range are possible, and an early decision on uprating is not required. A 137% increase in Mars orbit payload is obtained by use of common modules utilizing propellant transfer vs modules customized for each propulsion requirement for the 1982 opposition mission. (auth)

## Process Heat and Desalination Reactors

**21537** (AI-CE-Memo-59) HEAVY WATER ORGANIC COOLED REACTOR. PHASE B. DUAL PURPOSE FUEL ELEMENT STUDY. Final Report. Jesick, J. F.; Harding, R. A.; Young, R. H.; Menzel, G. P.; Staron, F. J.; Lee, R. R.; Churchill, J. R. (Atomics International, Canoga Park, Calif. Combustion Engineering, Inc., [Windsor, Conn.]). June 1967. Contract AT(38-1)-430. 368p. Dep. CFSTI.

Phase B of the Dual Purpose Task was primarily undertaken to determine, in the light of minimum energy cost criteria, an HWOCR fuel system and design which could be recommended as the basis for the conceptual design evaluation of 3,000 and 10,000 MW(t) dual purpose plants. Fifteen possible combinations of fuel, cladding and element configurations were considered. The four systems which were selected for detailed evaluation because of their superior performance potential for a dual purpose application in an HWOCR reactor are: (a) UC fuel clad with SAP in a rodded geometry, (b) $UO_2$ fuel clad with Zr in a rodded geometry, (c) U-metal fuel clad with Zr in a concentric ring geometry, and (d) U-metal fuel clad with Al in a concentric ring geometry. For these designs, operational and metallurgical limits were established on the basis of a reasonable extrapolation of current technology. In addition, the 1975 and 1985 economic ground rules established for the evaluation of reactors to be used for desalination were adopted. After establishment of operational limits, metallurgical limits, and the comparative economic ground rules, ranges of design parameters were selected to enable trends to be determined. These included variations of reactor coolant exit temperature, fuel area, organic volume fraction, etc. For each possible combination, thermal-hydraulic performance incorporating the appropriate nuclear power distributions was evaluated. General mechanical designs were developed and transmitted to Oak Ridge National Laboratory which established the fuel fabrication costs. Values of the initial and final fissile-fertile material were utilized in the calculation of the equilibrium fuel cycle costs. These costs were coupled with the appropriate reactor and plant capital costs to give the resulting total available energy costs. Each system was evaluated in the light of the established economic criteria and the results organized for comparative examination. Based on the 1985 economic ground rules, the most promising system in terms of minimum available energy costs appeared to be a 37-rod, SAP-clad UC element. The parameters for this design are given. An investigation initiated after completion of Phase B determined the economic effect of lowering the reactor outlet temperature of the HWOCR in a dual purpose application with high water to power ratio. The initial Phase B results had shown that the U-metal annular designs offer the best potential at low coolant exit temperatures. Therefore, U-metal-Zr annular designs were analyzed at reactor coolant exit temperatures below 600°F, the lower limit of the Phase B study. The 6 sq. in. (mass sectional area) design with three organic volume fractions and two organic coolants (OM and HB-40) was analyzed over a range of outlet temperatures down to a reactor inlet temperature of 250°F. A description of this analysis, its results, and the conclusions drawn are presented. (auth)

**21538** (NP-17802) COMPENDIUM OF PAPERS ON DESALINATION. (United Kingdom Atomic Energy Authority, Risley (England). Reactor Group). Oct. 1968. 180p. Dep.

Included are 18 papers on the physics, engineering, and economic aspects of the flash distillation process and on the development of other desalination methods. Three papers have been previously cited in NSA as abstracts 20: 40439, 22: 30292, and 22: 30294. An abstract was prepared for one other paper on the use of nuclear reactors for distillation systems. (H.D.R.)

*For an abstract of the individual paper see: 21539.*

**21539** (NP-17802, pp 145-62) SINGLE PURPOSE AND COUPLED DISTILLATION SYSTEMS. Clelland, D. W. (United Kingdom Atomic Energy Authority, Risley (England). Engineering Group).

Two designs of large dual purpose systems based on AGR and SGHW reactors are described and the economics of such systems are examined. The effect on cost trends of employing comparatively expensive steam, such as might be applicable in single purpose systems, is also examined. (UK)

**21540** OPTIMAL STEAM OPERATING TEMPERATURE ON COUPLING OF MULTISTAGE FLASH EVAPORATION PLANTS WITH GENERATING STATIONS POWERED BY CONVENTIONAL OR NUCLEAR FUEL. Kunst, B. (GHH-M.A.N.-Technik, Essen). Chem.-Ing.-Tech., 41: 104-9(Feb. 1969). (In German).

Optimum design data for large-scale plants based on the multistage flash evaporation process and operating in conjunction with steam or gas turbines powered by conventional or nuclear fuel were calculated for wide ranges of electrical performance and of desalination yield by means of an electronic computer. The limitations of the use of gas or steam turbines are established. (auth)

**21541** ANALYSIS OF SCIENTIFIC AND TECHNICAL DATA ON MULTIPURPOSE REACTOR INSTALLATIONS. Koryakin, Yu. I.; Loginov, A. A.; Tschernyaev, W. A.; Suponev, A. D.; Pachomova, S. A.; Montschinski, A. G. Desalination, 5: 201-16(1968). (In German).

Use of a low power organic cooled reactor for production of potable water as well as power is proposed. Technology acquired from the ARBUS reactor is summarized as a starting point. A typical flow diagram for a multipurpose reactor installation is shown; design bases are defined. The cooling systems and heat supply apparatus are described. The interrelation between the power and heat producing functions of the reactor is discussed; data are shown graphically. Cost analyses are detailed and are given for several nominal reactor power levels. 8 references. (M.L.S.)

## Marine and Portable Power Reactors

**21542** (EUR-4226) NUCLEAR RESEARCH SHIP "OTTO HAHN." Annual Report, 1967. (Gesellschaft fuer Kernenergieverwertung in Schiffbau und Schiffahrt m.b.H., Hamburg (West Germany)). Jan. 1969. Contract 009-64-7-PNID. 84p. (In German). Dep.

Construction during 1967 is described. The experiments carried out on the reactor core in the Geesthacht zero-power test facility are discussed. The installation of the pressure vessel on board and the completion of the control room are described. (auth)

**21543** GAMMA-RAY LEAKAGE THROUGH A JUNCTION BETWEEN LEAD AND CONCRETE WALLS. Miyasaka, Shunichi (Japan Atomic Energy Research Inst., Tokyo); Kanemori, Yoshihiko; Fukushima, Yutaka; Yamada, Takeshi. Nippon Genshiryoku Gakkaishi, 11: 144-9(1969). (In Japanese).

As part of a series of mock-up tests undertaken in relation to the shielding design for the first Japanese nuclear propelled ship, reactor $\gamma$-ray leakage through a part of the shielding forming the function between 15 cm thick lead and 75 cm thick concrete slabs with the lead wall abutting at right angles against the side of the concrete shielding is analyzed. The experimental results are expressed as functions of slit width, beam incident angle and point of observation. The observed data are compared with calculations based on ray-analysis for penetration components, and on single scattering method for streaming components. 10 references. (auth)

## Production Reactors

**21544** (CEA-CONF-1110) BEHAVIOR WITH TIME OF THE PRESTRESSED CABLES OF CASES G2/G3. Puyo [Andre]; Dupay [Francis] (Bureau d'Etudes A. Coyne et J. Bellier, Paris (France)). [nd]. 11p. (In French). (CONF-680645-1). Dep.

From Conference on Prestressed Concrete, Madrid, Spain.

The G2 and G3 reactors at Marcoule were the first of this type to use vessels of prestressed concrete for the pressurized vessel of the reactor and the biological shield. The cables were installed in such a way that they could be constantly monitored and readjusted to maintain the prestress forces. The monitoring and replacement of some of these cables without reactor shutdown is described. (J.S.R.)

**21545** (RL-GEN-1438) N-REACTOR SECONDARY COOLING SYSTEM RESPONSE TO AN A-BUS LOSS. Conn, W. G. (General Electric Co., Richland, Wash. Hanford Atomic Products Operation). Apr. 28, 1967. 17p. Dep. CFSTI.

The expected cooling system response to an A-bus loss under various plant operating conditions is described. Procedures that will minimize the transient effects on the plant are recommended. (auth)

## Reactor Theory

*Refer also to abstracts 21227 and 21228.*

**21546** (AEEW-R-243) MOCUP: A MONTE CARLO PROGRAMME FOR ESTIMATING RESONANCE ESCAPE IN COMPLEX GEOMETRIES. Bannister, G. W.; Basher, J. C.; Pull, I. C. (Atomic Energy Establishment, Winfrith (England)). Aug. 1968. 65p. Dep. CFSTI. UK 9s.

MOCUP is a Monte Carlo program written for the IBM 7090 computer in FAP, the symbolic machine language. The code has been used primarily for estimating resonance escape probability and its variation with temperature in a variety of reactor systems. It has also been used as a test-bed for the development of a new Monte Carlo treatment of thermal neutron scattering. Features of the program are the geometrical complexity it can handle, including bundles of fuel rods and other rods of different types arbitrarily placed in the coolant channel, and the fine detail of the tabulated resonance data which can be accepted. The capabilities of the code, data preparation, results available, operational features and Monte Carlo methods embodied in the program are described. (auth) (UK)

**21547** (ANL-Trans-716) APPLICATION OF THE COLLISION THEORY FOR THE CALCULATION OF REACTIVITY VALUES. Fischer, E. A. Translated by Elmar K. Wilip (Argonne National Lab., Ill.), from a German report. 12p. Dep. CFSTI.

Reactivity worth measurements on samples in critical assemblies are usually interpreted under conventional perturbation theory assumptions. Presented is a more exact transport theory analysis of reactivity values, in which the spatial interaction of the resonance flux and self-shielding effects of the sample are considered. (H.D.R.)

**21548** (CEA-R-3691) CALCULATION OF REACTIVITY BY DIGITAL PROCESSING. Hedde, Jean (Commissariat a l'Energie Atomique, Saclay (France). Centre d'Etudes Nucleaires). Dec. 1968. 172p. (In French). Dep.

Thesis.

With a view to exploring the new possibilities offered by digital techniques, a description is given of the optimum theoretical conditions of a computation of the realtime reactivity using counting samples (obtained from a nuclear reactor). The degree to which these optimum conditions can be attained depends on the complexity of the processing which can be accepted. A compromise thus has to be made between the accuracy required and the simplicity of the equipment carrying out the processing. An example is given, using a relatively simple structure, which gives an accuracy of the results obtained over a wide range of the reactor power. (auth)

**21549** (EURFNR-583) STABILITY PROBLEMS OF STEAM-COOLED FAST REACTORS. Frisch, W. (Kernforschungszentrum, Karlsruhe (West Germany). Institut fuer Reaktorentwicklung). Translation of report KFK-759. 106p. Dep. CFSTI.

Work Performed under United States–Euratom Fast Reactor Exchange Program.

Calculations are presented on stability problems in a conceptual fast breeder reactor containing oxide fuel and cooled by fast flowing steam. The core stability is analyzed in terms of the neutron kinetics, power production, thermodynamics, and reactivity feedback. The influence of coolant circuit dynamics is also considered. (H.D.R.)

**21550** (WCAP-7082) LAMB: A CODE TO CALCULATE PROMPT NEUTRON LIFETIME AND EFFECTIVE DELAYED NEUTRON FRACTION IN FAST REACTORS. Williamson, J. W. (Westinghouse Electric Corp., Madison, Pa. Advanced Reactors Div.). Aug. 1967. 40p. Dep. CFSTI.

LAMB is a one-dimensional computer code designed specifically to calculate the prompt neutron lifetime, and the effective delayed neutron fraction. The code is easy to use. If fluxes as punched out by the MOBI code are used, the input which the user must supply is minimal. LAMB is a simple code written entirely in 6600 FORTRAN-IV. It is easy to modify and users who find its limitations restrictive should consider having the code changed to suit their specific problems. (auth)

**21551** NEKOTORYE VOPROSY NADEZHNOSTI YADERNYKH REAKTOROV. (Some Problems of Nuclear Reliability). Klemin, A. I.; Strigulin, M. M. Moscow, Atomizdat, 1968. 352p.

Aspects of reactor and reactor component reliability analysis and testing are examined. The principle positions of reliability theory in reactor construction are discussed, and methods for the practical application of this theory are presented. Emphasis is placed on projection of the thermodynamic characteristics of reactors, including calculation methods for accidental variations in heat removal conditions, the determination of quantitative indexes of thermotechnical reliability, and methods for estimating the thermohydraulic stability of channels in the core. Methods of statistical data treatment and methods for estimating the accuracy of statistical characteristics are presented. The information is directed toward specialists in the reactor field, but can also be useful to postgraduate students in engineering and the physical sciences. (tr-auth)

**21552** DOPPLER COEFFICIENTS FOR FAST REACTORS. Nakamura, Kunihiko; Ohta, Masao; Nishihara, Hiroshi (Kyoto Univ.). Tech. Rep. Eng. Res. Inst., Kyoto Univ., No. 142, 1-52 (Aug. 1968).

In order to calculate the Doppler coefficient for fast reactors theoretically, the required resonance level parameters for fissile and fertile elements were tabulated in the energy region between 50 eV and 200 keV based on data of mostly Nordheim and Schmidt. The $Q_E$ values defined by Nicholson based on Method A for strongly overlapping resonance regions and Method B for isolated resonance regions were calculated for survey with the use of those level parameters. The Doppler coefficients for fast reactors with homogeneous core-region compositions can be easily calculated with the use of these $Q_E$ values. (auth)

**21553** MATHEMATICAL MODEL FOR DETERMINATION OF THE FAILURE PROBABILITY OF REACTOR COMPONENTS.

Knecht, O.; Zeibig, H. (INTERATOM, Bensberg, Ger.). Atomwirt., Atomtech., 14: 87-92(Feb. 1969). (In German).

A mathematical model for determination of failure probabilities for reactor components and systems subjected to thermal and mechanical loadings is described. Failure rate probability functions and probability distributions are derived; a failure rate probability for the whole system is developed. An expression for the relation of failure probability and safety factors is given. Effects of creep and fatigue on the components are taken into account. 20 references. (M.L.S.)

**21554** LIQUID/VAPOR ACTION IN A VESSEL DURING BLOWDOWN. Moody, F. J. (General Electric Co., San Jose, Calif.). J. Eng. Power., 91: 53-61(Jan. 1969).

Vapor bubble rise forms the basis for a theoretical study of liquid/vapor action in a saturated system during blowdown. Methods are developed and demonstrated for predicting time and space dependent mixture properties. Graphs are presented for estimating the time-dependent mixture level during steam, water, and mixture blowdowns from 1000 psia. Theoretical mixture levels are compared with vapor blowdown experiments. Although calculations strongly depend upon bubble rise velocity in the liquid, reasonable agreement with data is shown. 10 references. (auth)

**21555** NEUTRON DENSITY VERSUS FLUX WITH REGION-AVERAGED SPECTRA. Bonalumi, R. (CISE, Milan). Energ. Nucl. (Milan), 16: No. 4, 42-5(Apr. 1969).

A typical procedure used in reactor calculations is to obtain region-averaged cross sections by a few-region multigroup calculation and to generate a detailed neutron flux distribution by a one-group many-region calculation using the region-averaged spectra. The accuracy of this procedure for predicting reaction rate and neutron density distribution is analyzed for a simplified two-region thermal spectrum calculation. (H.D.R.)

**21556** NEUTRON LEAKAGE DELAY-TIME DISTRIBUTION IN REACTOR KINETICS. Belleni-Morante, A. (Univ., Florence); Busoni, G.; Motta, M. Energ. Nucl. (Milan), 16: No. 4, 14-21(Apr. 1969).

An integro-differential kinetics equation is derived, involving the distribution of the neutron leakage delay-time. The results of calculations performed for two fast critical assemblies, using such an equation, are then given. (auth)

**21557** NASA METHOD FOR CALCULATING UNIFORM CLUSTERS. Bonalumi, R. (CISE, Milan). Energ. Nucl. (Milan), 16: No. 4, 1-13(Apr. 1969).

A synthetic method is proposed for detailed flux calculations in a uniform cluster (equal and equally spaced rods): the method is based on first collision probabilities, but gets rid of the so-called flat-flux approximation. The basic idea is to give neutron flux by superimposing two components: the former due to neutron sources inside the cluster, the latter due to neutron injection from outside into the source-free cluster. The method compares fairly well with CLUCOP. (auth)

### *Experimental Applications*

*Refer also to abstracts 21517, 21524, and 21571.*

**21558** (AI-AEC-12774) CALCULATION OF REACTION RATES IN SMALL PHYSICAL REGIONS BY MEANS OF A NEW NON-MULTIGROUP ADJOINT MONTE CARLO TECHNIQUE. Levitt, L. B.; Lewis, R. C.; Spanier, J. (Atomics International, Canoga Park, Calif.). Mar. 15, 1969. Contract AT(04-3)-701. 42p. Dep. CFSTI.

The use of adjoint Monte Carlo in the study of reaction rates in small spatial regions of a reactor has an advantage over direct Monte Carlo techniques, in that it samples random walks from the "detector" (the small region under study) to the neutron source, rather than the reverse procedure which actually occurs. A new adjoint Monte Carlo technique is described which appears to be very useful for solving problems in the slowing-down region below the threshold for inelastic scattering. The basis for the technique is the idea of exactly reversing direct Monte Carlo random walks, first used in the combined adjoint-direct Monte Carlo procedure developed for analysis of resonance integral experiments. The extension of the backward random walk to a complete adjoint Monte Carlo calculation permits the calculation of absolute reaction rates, whereas the combined technique was limited to relative reaction rates. The mathematical justification for this new technique must show that the resulting procedures exhibit some form of importance weighting. This is done by relating this technique to a multigroup adjoint technique (introduced by Gelbard and Spanier to solve problems in the thermal energy range) in such a way that it may be viewed as a logical extension of their work to continuous-energy slowing-down regions, thereby demonstrating a connection with dual importance sampling. Numerical results are provided which illustrate the gains in efficiency resulting from the use of this new technique. 13 references. (auth)

**21559** (GA-9140) FAST REACTOR SPECTRUM MEASUREMENTS. Quarterly Progress Report for the Period Ending October 31, 1968. Preskitt, C. A.; d'Oultremont, P.; Neill, J. M.; Young, J. C. (Gulf General Atomic, Inc., San Diego, Calif.). Nov. 1, 1968. Contract AT(04-3)-167. 31p. Dep. CFSTI.

Experimental activities primarily concentrated on the loading and spectral measurements for assemblies STSF-3 and STSF-4. These assemblies were zoned versions of Assembly 6 of ZPR-6, a 4000-liter core, for which critical experiments were recently performed. This assembly of ZPR-6 had a critical mass of 1817 kg of $^{235}U$ and represents a typical composition for an oxide fueled LMFBR. Other experimental studies included: (1) a final calibration of the lithium glass detector used for many of the measurements, and (2) an in-core dieaway measurement. Analytical work was performed in support of the loading operations for STSF-3 and -4 and calculations initiated for the analysis of data from these systems. Some effort was devoted to the formulation of a new data reduction code designed to improve the accuracy of corrections due to the finite dieaway time of the systems studied. (auth)

**21560** (RCN-101) REACTOR NOISE: A STUDY OF NEUTRONIC FLUCTUATIONS IN LOW-POWER NUCLEAR REACTORS, WITH SPECIAL EMPHASIS ON ACCURATE TIME-DOMAIN ANALYSIS. Dragt, J. B. (Reactor Centrum Nederland, Petten). Oct. 1968. 225p. Dep.

Reactor noise measurements with neutron-sensitive ionization chambers, digital measuring techniques, and by means of digital computers are described. The theory of the kinetics and the noise of zero-power reactors for several reactor models is presented. The accuracy to be expected in reactor noise experiments (with one as well as two detectors) is calculated. The accuracy of parameters derived from the noise is considered. Two-detector experiments are shown not to be essentially better. A detailed description of the experimental set-up is given on reactors, instrumentation, computer programs and analysis. Experimental results are presented. For a simple reactor the results are compared with a simple theory. Reactor parameters determined from the noise are corrected for space effects. For two coupled reactor cores the coupling factor is determined with good accuracy. In a third group of experiments the results of the correlation function analysis are compared with several other kinetic techniques. Conclusions are summarized and practical applications are discussed. (auth)

**21561** (Y-CDC-6) SOME EFFECTS OF INTERSPERSED MODERATION ON ARRAY CRITICALITY. Thomas, J. T. (Union Carbide Corp., Oak Ridge, Tenn. Y-12 Plant). Mar. 14, 1969. Contract W-7405-eng-26. 24p. Dep. CFSTI.

Monte Carlo calculations have been made of experimental reflected critical arrays of U(93.2) metal cylinders exploring the effect on criticality of introducing hydrogenous and nonhydrogenous materials as moderators both separately and in combinations. It was determined that as little as 0.32 cm of steel surrounding the individual units of a reflected array is sufficient to maintain subcriticality independent of the amount and distribution of interspersed hydrogenous moderator present. Some benefits to nuclear safety specifications for storage and transport of fissile materials are suggested, and an example of nuclear safety evaluation provided by these analyses is presented. (auth)

## Reactor Components, Fuels, and Accessories

*Refer also to abstracts 19877, 19946, 20054, 20055, 20463, 20464, 20526, 20530, 20531, 20533–20537, 20539–20541, and 20557.*

**21562** (BNWL-991) OPTIM: A MULTIDIMENSIONAL NON-LINEAR OPTIMIZATION CODE. Haffner, D. R. (Battelle-Northwest, Richland, Wash. Pacific Northwest Lab.). Dec. 1968. Contract AT(45-1)-1830. 63p. Dep. CFSTI.

The optimization computer code, OPTIM, is designed to optimize reactor fueling nonlinear problems iteratively for ten or less independent variables by applying a differential approach to a quadratic function with interaction terms derived from a least square fitting technique to a known sample set of data. The program is written in FORTRAN 5 for the UNIVAK 1108 digital computer. 5 references. (auth)

**21563** METHOD AND APPARATUS FOR MAKING PEAS-IN-A-POD NUCLEAR REACTOR ELEMENT. Handwerk, Joseph H.; White, David E. (to United States Atomic Energy Commission). U. S. Patent 3,425,115. Feb. 4, 1969.

A method of, and means for producing, a fuel element for a nuclear reactor are described by which a metal tube is filled with spherical fuel bodies of diameter about equal to the inner diameter of the tube, a punch is used to create indentations in the tube between the fuel bodies in a regular pattern, the tube is sealed at the ends and subjected to isostatic pressure to collapse the tube about the spherical bodies. (AEC)

**21564** CONTROL-ROD DRIVING SEALED PRESSURE TUBE. Inoue, Tatsunosuke (to Hitachi Ltd.). Japanese Patent 1968-24839. Oct. 26, 1968. Filed Feb. 14, 1966.

An improvement to maintain an equivalent distance between the movable member (connected to a control rod) and the electromagnetic iron core (outside the cylinder) is described. The wall of the pressure tube is made up by joining alternately a section of a magnetic material and a section of a non-magnetic material; this provides magnetic substance between the iron core and the movable member. The magnetic-flux short circuit is prevented by the non-magnetic substance. (NSA of Japan)

**21565** DEVICE FOR JOINING FUEL-ROD CLUSTERS. Iwai, Syozo (to Mitsubishi Atomic Power Industry, Inc.). Japanese Patent 1968-23105. Oct. 4, 1968. Filed Nov. 27, 1964.

The method is used to join fuel-rod clusters in the proper, axial line in a pressure tube; in addition, the flow resistance and the parastic neutron absorption are minimized. The fuel rods in a cluster are supported at the end by means of a crate plate. In joining the two clusters, the support plate of one cluster is concave and that of the other cluster is convex, thus enabling the two clusters to join each other in the proper, axial line. The position of contact is at the inclined part of the crate plates. (NSA of Japan)

**21566** SUPPORT FOR FUEL ELEMENTS. Suzuki, Masanori (to Hitachi Ltd.). Japanese Patent 1968-23106. Oct. 4, 1968. Filed Mar. 25, 1965.

The method proposed has advantages such as easy movement of control rods and easy support for the fuel elements. Vertical fuel elements are arranged by an upper grid support. Each square of the grid holds four fuel elements whose cross section is square; a crisscross control rod is inserted among the four fuel elements. A plate is installed at each intersection on the grid, to hold down the fuel elements. (NSA of Japan)

**21567** THE EUROPEAN ATOMIC INDUSTRY AND ITS MARKET. PART 5. FUEL ELEMENTS FOR NUCLEAR REACTORS. Fernet, P.; Pantleon, M. (EURATOM, Brussels). Atomwirt., Atomtech., 14: 80-4(Feb. 1969). (In German).

The production of fuel elements in Europe is discussed. Fuel element manufacturing processes are described for gas-graphite, light water, high temperature, and fast breeder reactors. The suppliers and their cooperation are discussed for Germany, Belgium, France, Italy, and The Netherlands; fuel element and cladding manufacturers are listed by country for the EURATOM countries. (M.L.S.)

**21568** HIGH-STRENGTH STEELS FOR POSSIBLE USE IN PRESTRESSED CONCRETE NUCLEAR REACTOR VESSELS. Parker, Earl R. (Univ. of California, Berkeley). Nucl. Eng. Design, 8: 440-2(1968).

The micro and macro mechanisms of fracture are reviewed. The features that limit the ductility and toughness of steels having yield strengths above 100,000 psi are emphasized. Comparisons are made between the properties of quenched and tempered low-alloy steels, maraging steels and some laboratory steels that are now being investigated. Possible upper limits for strength and ductility are considered. 10 references. (auth)

**21569** PRESSURE SUPPRESSION CONTAINMENT DESIGN-CURRENT STATE OF THE ART. Miller, D. R. (General Electric Co., San Jose, Calif.). J. Eng. Power, 91: 13-20 (Jan. 1969).

A summary of the thermodynamic design limits for pressure suppression containments for nuclear reactors is presented. Those parameters which must adhere to tested values are tabulated and discussed. An analytical model is described and is shown to accurately predict the existing test data. A graphical technique for predicting the transient peak containment pressure, based on the model, is presented for use in containment design. 7 references. (auth)

**21570** MANUFACTURING OF FUEL ELEMENTS. van den Honert, A. Atoomenergie Haar Toepass., 11: 45-8(Feb. 1969).

Techniques for the production and quality control of reactor fuel elements by Philips are described. (D.C.C.)

**21571** CALCULATION OF P.C.P.V. PRESTRESSING FORCES. Carmichael, G. D. T.; Irving, J. (Berkeley Nuclear Labs., Eng.). Nucl. Eng. Design, 8: 487-99(1968).

An integrated system of stress analysis programs is being developed at the Berkeley Nuclear Laboratories to assess the conditions in the plant operated by the C.E.G.B., and to study the effects of long-term operation. A knowledge of the body and boundary forces sustained by a Prestressed Concrete Pressure Vessel is required to completely evaluate the state of stress in the vessel. A computer program has been written to calculate these forces and complete the part of the stress analysis system devoted to P.C.P.V. appraisal. 13 references. (auth)

**21572** NERATOOM GROUP. Gestel, W. D. J. Atoomenergie Haar Toepass., 11: 49-52(Feb. 1969).

A description of the Neratoom Group organization and operation is presented. A review of the growth in reactor component orders and research performed by the Neratoom Group is analyzed. (D.C.C.)

**21573** MANUFACTURE OF NUCLEAR REACTOR PRESSURE VESSELS (WITH PARTICULAR REFERENCE TO A 188 INCH (4800 mm) INSIDE DIAMETER PRESSURE VESSEL). van Veen, M. C. Atoomenergie Haar Toepass., 11: 38-44(Feb. 1969).

The manufacture of large steel pressure vessels for reactors is discussed. Three critical phases of the manufacture that are described include: design; fabrication; and quality control. (D.C.C.)

**21574** INSTRUMENTATION IN PRESTRESSED CONCRETE CONTAINMENT STRUCTURES. Bekowich, R. S. (Bechtel Corp., San Francisco). Nucl. Eng. Design, 8: 500-12(1968).

Instrumentation programs developed for several prestressed concrete containment structures currently under construction in the United States are described. Instrumentation programs of prestressed concrete nuclear reactors in Europe are reviewed. Pertinent aspects of selecting type and location of instruments and preparation of gages installed in wet concrete on the steel liner, reinforcing bars, and prestressing tendons are discussed. The requirements utilization of data acquisition systems are presented with examples of data reduction and evaluation. (auth)

**21575** STRUCTURAL DESIGN CRITERIA FOR SECONDARY CONTAINMENT STRUCTURES. Halligan, D. W. (Bechtel Corp., San Francisco). Nucl. Eng. Design, 8: 427-34(1968).

The basic structural design philosophy and criteria for reactor secondary containment shells is developed. Considering the several loading conditions to which the structure may be subjected, the range of allowable stresses as they relate to desired performance characteristics under various combinations of loadings is discussed. There are three general conditions under which the structure must meet appropriate stress criteria: as a long-term plant enclosure subjected to normal live znd dead loads; as a protective structure for the nuclear steam supply system subjected to abnormal external loads and forces such as tornadoes, hurricanes, maximum possible earthquake, and missiles that might be generated by a tornado, turbine failure, or airplanes; and as a containment structure subjected to internal pressure and temperature as a result of a major rupture of the main coolant system. (auth)

**21576** PRESTRESSED CONCRETE REACTOR PRESSURE VESSEL WITH SUPPORTING CONCRETE. Hofmann, Hans (Swiss Federal Inst. for Reactor Research, Wuerenlingen). Nucl. Eng. Design, 8: 467-70(1968). (In German).

A prestressed concrete reactor pressure vessel design consisting of an outer layer of load-carrying prestressed concrete and an internal Swiss-cheese-shaped concrete structure housing the reactor core and other main components (e.g., steam generators, turbine-generators, etc.) in its cavities is described. The internal concrete structure (designated as "Stiltzbeton") can be constructed to provide good radiation shielding and thermal insulation properties, while satisfactorily retaining its load bearing functions. By this structural concept a high degree of safety can be achieved at relatively low cost. (auth)

**21577** NUCLEAR POWER PLANT PROTECTIVE SYSTEM EMPLOYING LOGIC MATRICES. Bevilacqua, Frank (to Combustion Engineering, Inc.). U. S. Patent 3,425,903. Feb. 4, 1969. Filed Sept. 15, 1967.

A nuclear reactor safety control system is described. The system consists of multiple independent sensing devices employed to monitor each of a number of reactor operating variables. Operation of the reactor may be terminated whenever more than one of the sensing devices associated with any one variable simultaneously respond to a present condition of the monitored variable. (Offic. Gaz.)

**21578** IMPROVEMENTS IN OR RELATING TO SHOCK ABSORBER DEVICES. Bennet, John; Broughton, Kenneth John (to United Power Co., Ltd.). British Patent 1,144,771. Mar. 12, 1969. Filed Mar. 12, 1965.

Shock absorber devices are described which are intended primarily for installation at the base of the fuel channels of a solid moderator and solid fuel nuclear reactor. The shock absorbers are designed for the possibility of fuel becoming detached from handling devices and falling back into the reactor core. The device comprises a tube which, in use, is aligned with the line of fall of a component, together with a plug which is an interference fit within the tube. When the device is subjected to the shock of a falling object, the plug passes along the tube and deforms the wall. The plug carries an axial extension which is a sliding fit in the tube and which prevents buckling of the plug and tube out of alignment. The device may include a catch pot for falling debris. It may be arranged that the residual elastic recovery of the deformed portion of the tube acts to trap the plug at the end of the stroke, thus eliminating rebound. The plug and tube may be held together against safe loading by a shear pin. Passage may be afforded for reactor coolant fluids. The plug may carry a superstructure for supporting a string of fuel elements. (UK)

**21579** NUCLEAR REACTOR HYDRAULIC CONTROL DRIVE SYSTEM. Ripley, Charles C. (to United States Atomic Energy Commission). U. S. Patent 3,438,856. Apr. 15, 1969.

A nuclear reactor control system is described in which a horizontal beam connected to a hydraulic actuated piston in a vertically disposed cylindrical tube supports and positions a curtain of neutron reflecting chains within a nuclear reactor core to regulate reactivity. Multiple neutron absorbing rods are mounted on the top of the beam also to be positioned within the reactor core to regulate reactivity. A pressure gage calibrated in units of length relevant to the weight of the chain being lifted by the beam indicates the vertical position of the beam. The remainder of the chain rests on a tray or the bottom end of the curtain chain is attached to a supporting wall. (AEC)

**21580** FUEL CYCLE IN BELGIUM. Vanden Bemden, E. Bull. Belgicatom, 13: No. 3/4, 11-15(Oct.-Dec. 1968). (In French).

The principal types of reactor fuels under development and a typical oxide fuel cycle are examined briefly. Schematic representations of thermal and fast reactor fuel cycles are presented, and fuel cycle economics are discussed. Efforts toward the development of a fuel cycle capability in Belgium are summarized. (H.D.R.)

**21581** NUCLEAR REACTOR FUEL ELEMENT ASSEMBLIES. Campbell, Ronald Hugh; Holmes, John Arthur Godfrey; Saunders, Alan Charles Anthony (to United Kingdom Atomic Energy Authority). British Patent 1,147,432. Apr. 2, 1969. Filed Nov. 30, 1965.

Reference is made to fuel element assemblies of the cluster type. Each assembly has a cluster of spaced parallel fuel elements with a cellular grid or grids disposed between the ends of the cluster for spacing. Each sheathed fuel element has a continuous column of fuel pellets contained within an aligned series of outer sheaths, the latter being end joined by internal sleeves to define waisted portions of the fuel elements of less outside diameter than the sheaths, the waisted portions being accommodated within cells of the spacing grid or grids, and the sleeves being joined to the grids. The fuel element assembly may have a number of clusters of spaced parallel fuel elements, the clusters being arranged end-to-end. The outer sheaths, internal sleeves, and spacing grids may be of Zr alloy. (UK)

**21582** A SPACER FOR THE FUEL ASSEMBLIES OF NUCLEAR REACTORS. (to Allmanna Svenska Elektriska Aktiebolaget). British Patent 1,147,233. Apr. 2, 1969. Priority date July 2, 1965, Sweden.

REACTOR FUEL ELEMENTS— spacers for rod-type, description of right angle strip springs for polygonal ring (D.C.C.)

# GENERAL

**21583** (ANL-7495) SPECIAL-PURPOSE LANGUAGE FOR LEAST-SQUARES FITS. Gabriel, Marian (Argonne National Lab., Ill.). Sept. 1968. Contract W-31-109-eng-38. 79p. Dep. CFSTI.

A time-saving user language for performing least-squares fits to data is described. The processor is divided into three sections: a translator which generates the required FORTRAN code; a data processor which rearranges all the numerical data into valid input to FORTRAN programs; and the Davidon fitting procedure. Source listings for all codes and cataloged procedure listings are included. (W.H.K.)

**21584** (ANL-7511) COMPARISON OF SEVERAL ADAPTIVE NEWTON-COTES QUADRATURE ROUTINES IN EVALUATING DEFINITE INTEGRALS WITH PEAKED INTEGRANDS. Hillstrom, K. E. (Argonne National Lab., Ill.). Nov. 1968. Contract W-31-109-eng-38. 26p. Dep. CFSTI.

The performance of five different adaptive quadrature schemes, based on Newton-Cotes (2N + 1)-point rules (N = 1, 2, 3, 4, 5) are compared for approximating the sets of definite integrals $\int_{-1}^{1} (x^2 + p^2)^{-1}\,dx$, $\int_{0}^{1} x/(1.1 - x)^p\,dx$, and $\int_{0}^{3} x^p(x - 2)\,(x - 3)\,dx$ with relative accuracy $\epsilon$. (auth)

**21585** (AWRE-O-48/68) SPLINE: A FORTRAN COMPUTER PROGRAM FOR THE EVALUATION OF SETS OF EXPERIMENTAL DATA USING CUBIC SPLINE CURVE FITTING AND A STATISTICAL THEORY OF UNKNOWN SYSTEMATIC ERRORS. Horsley, A.; Price, J. A. (Atomic Weapons Research Establishment, Aldermaston (England)). Sept. 1968. 63p. Dep. CFSTI. UK 9s.

The S3 (Fortran language) program SPLINE can be used to graduate sets of experimental data using a cubic spline curve fitting method and a statistical theory of unknown systematic errors. Descriptions of the input specification and the output facilities, and a listing of the program are given. The program is at present compiled for operation on the ICT ATLAS 2 computer. (auth)

**21586** (AWRE-O-65/68) THE DEVELOPMENT OF A COMMERCIALLY AVAILABLE EXPLOSIVE DONOR FOR THE AWRE SMALL SCALE GAP TEST. Chick, M. (Atomic Weapons Research Establishment, Aldermaston (England)). Oct. 1968. 20p. Dep. CFSTI. UK 3s.

The development of a donor which can be assembled from commercially available components is described, for use in the AWRE small scale gap test for determining the shock sensitivity of explosive charges. (UK)

**21587** (CTC-10) FACTORABLE DETERMINANTS. Bowman, K. O.; Shenton, L. R. (Union Carbide Corp., Oak Ridge, Tenn. Computing Technology Center). Mar. 6, 1969. Contract W-7405-eng-26. 15p. Dep. CFSTI.

A solution for a bordered continuant matrix which arises in the solution of a linear system of differential equations associated with a statistical estimation problem is given. The matrix is evaluated by successive application of premultiplication and postmultiplication techniques which allow the determinants to be factored into a power of n. The resultant determinants are included. (M.L.S.)

**21588** (DP-929 (Rev. 1) (Suppl. 1)) PUBLICATIONS, 1968. Hilborn, H. S. (comp.) (Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.). Feb. 1969. Contract AT(07-2)-1. 24p. Dep. CFSTI.

A bibliography of research and development reports, journal articles, contributions to books, computer programs and other items published by Du Pont under its contract with the Atomic Energy Commission is presented. Subject and author indexes are included. (B.G.D.)

**21589** (DP-1182) COMPUTER PROGRAM FOR CIRCULATION AND CONTROL OF LIBRARY JOURNALS. Feldman, Myra S.; Maddox, Judith H. (Du Pont de Nemours (E. I.) and Co., Aiken, S. C. Savannah River Lab.). Jan. 1969. Contract AT(07-2)-1. 39p. Dep. CFSTI.

A FORTRAN IV program (JURN), written for the IBM System 360/65, automates the circulating and listing of journals in the technical library of the Savannah River Laboratory. The program provides circulation slips, renewal notices, and lists of circulating and reference copies of journals, in addition to complete information on holdings. The program is a revision of an earlier FORTRAN II program (DP-970). (auth)

**21590** (EUR-4213) STATISTICAL ANALYSIS OF CONCEPT CO-ORDINATION DOCUMENTATION SYSTEMS. Romerio, G. F.; Cricchio, A. (European Atomic Energy Community, Luxembourg. Center for Information and Documentation). Sept. 24, 1968. 26p. Dep.

The basic principles for a statistical analysis of concept coordination documentation systems are outlined and developed starting from the representation matrix of the system. The concept of ideal log-normal system is introduced, where the distribution laws for the descriptors' assignment frequencies and for the documents' coordination levels are both log-normal with the same median. The statistical analysis of EURATOM/CID Nuclear Documentation System is then performed and its characteristic parameters measured. Finally, a study of the dynamics (i.e., the variation of the number of descriptors with the number of documents indexed) in a documentation system is carried out starting from a simple working hypothesis. (auth)

**21591** (GA-8298) COMPUTATIONAL METHODS IN SOLID MECHANICS AND STRESS ANALYSIS. Rashid, Y. R. ([Gulf General Atomic, Inc., San Diego, Calif.]). [1968]. Contract W-7405-eng-26; Subcontract 2848. 27p. Dep. CFSTI.

For Oak Ridge National Lab., Tenn.

Progress made in various areas using the finite element method is summarized. The finite element method for problem solution in initial boundary value problems; analysis of two- and three-dimensional solids, plates and shells, and heat conduction and diffusion; inelastic analysis of prestressed concrete pressure vessels; and the dynamic analysis of lumped parameters and systems is discussed. (F.S.)

**21592** (GA-9076) SAFE-2D: A COMPUTER PROGRAM FOR THE STRESS ANALYSIS OF PLANE AND AXISYMMETRIC COMPOSITE STRUCTURES. A USER'S MANUAL. Cornell, D. C. (Gulf General Atomic, Inc., San Diego, Calif.). Feb. 12, 1969. Contract W-7405-eng-26; Subcontract 2848. 45p. Dep. CFSTI.

For Oak Ridge National Lab., Tenn.

Input instructions of a computer program for the elastic analysis of heterogeneous plane and axisymmetric structures, hereafter called two-dimensional structures, are outlined. Plane structures are described in a Cartesian (x-y) coordinate system and can be in a condition of plane stress or plane strain. Axisymmetric structures involving axisymmetric stress states are described in the cylindrical coordinate system r-$\theta$-z. A geometry which is part plane and part axisymmetric can be combined in a single analysis in which the axisymmetric part is treated isotropically and the plane part is treated orthotropically with no stiffness in the hoop direction. The program, SAFE-2D, is written in the FORTRAN IV language and compiled for the UNIVAC-1108 digital computer. (auth)

**21593** (GA-9231) APPLICATION OF PHOTOINDUCED REACTIONS TO NUCLEAR MATERIALS SAFEGUARDS PROBLEMS. Quarterly Progress Report, October 1-December 31, 1968. Bramblett, R. L.; Gozani, T.; Ginaven, R. O.; Kull, L. A.; Rundquist, D. E. (Gulf General Atomic, Inc., San Diego, Calif.). Jan. 31, 1969. Contract AT(04-3)-167. 47p. Dep. CFSTI.

The nuclear materials safeguards techniques development is based on the use of a low energy electron accelerator to produce measurable photoneutron and photofission reactions characteristic of the isotopic composition and quantity of fissile or fertile material in a bulk sample. Emphasis during the report period was given to a mock assay experiment, preparation for realistic assays, and design of a transportable assay LINAC. (H.D.R.)

**21594** (IFVE-SVM-68-30-K) REPORT ON A COMPILER REALIZING THE FORTRAN LANGUAGE FOR MINSK-22. Sokolov, S. N.; Kalinchenko, P. A.; Lupashina, I. S.; Makarov, V. A.; Markov, A. S.; Popova, I. V. (Gosudarstvennyi Komitet po Ispol'zovaniyu Atomnoi Energii SSSR, Serpukhov. Institut Fiziki Vysokikh Energii). 1968. 20p. (In Russian). Dep. CFSTI.

A compiler which realizes FORTRAN-IHEP language compatible with CERN FORTRAN is described. The general structure of the compiler and the system of syntax diagnostics and exploitational characteristics are described. A LOAD statement, giving the possibility of program sectioning, is defined. (auth)

**21595** (K-1772) PHOSPHORUS TRIFLUORIDE CYLINDER FAILURE. Ritter, R. L.; Bensey, F. N.; Nolan, T. A.; Pickrell, P. W.; Ziehlke, K. T. (Oak Ridge Gaseous Diffusion Plant, Tenn.). Apr. 3, 1969. Contract W-7405-eng-26. 12p. Dep. CFSTI.

A mild steel, high pressure gas cylinder containing phosphorus trifluoride failed in storage about 15 months after filling. Microscopic and metallographic examinations of the failed cylinder have shown the failure to have probably been the result of stress corrosion of the mild steel. The similarity to failure of carbon monoxide gas cylinders is pointed out. Specific recommendations for future use and storage of phosphorus trifluoride cylinders are presented. These include among others limiting the filling pressure to less than 1000 psia and a maximum period of storage not to exceed one year. (auth)

**21596** (LA-4050) GENERATION OF HIGH-PRESSURE ISOTHERMS FOR LIQUID AND SOLID SODIUM. Neal, T. R. (Los Alamos Scientific Lab., N. Mex.). Nov. 18, 1968. Contract W-7405-eng-36. 14p. Dep. CFSTI.

The objective of this report is to construct isotherms of sodium by calculating the isothermal compressibility. A simple form for the electron-ion pseudopotential allows the effective ion-ion interaction to be readily determined. In the case of liquid sodium, this determination is used in turn to construct a hard sphere model for the structure factor. A model of liquid sodium which disregards certain electron-electron effects is then examined to see where those effects become important. Finally, a simple calculation for the compressibility with those effects included is used to generate isotherms for solid and liquid sodium. The isotherms seem to agree reasonably well in the pressure region where experimental data are available. (auth)

**21597** (LA-4059) EQUATION OF STATE FOR SHOCKED POLYURETHANE FOAM. Mader, Charles L.; Carter, William J. (Los Alamos Scientific Lab., N. Mex.). Nov. 22, 1968. Contract W-7405-eng-36. 51p. Dep. CFSTI.

The experimentally observed behavior of systems of high explosives, low density (0.5- and 0.3-g/cc) polyurethane foam, and metals can be numerically reproduced if the foam is assumed to decompose and the decomposition products are described by a BKW equation of state. (auth)

**21598** (MLM-1550) CONTINUOUS FLOW MEASUREMENTS OF THERMOSETTING PLASTICS WITH THE OSCILLATING DISK RHEOMETER. Brodbeck, R. M.; Hartzel, L. W. (Mound Lab., Miamisburg, Ohio). Mar. 7, 1969. Contract AT(33-1)-Gen-53. 18p. Dep. CFSTI.

An oscillating disk rheometer is being used to measure the flow properties and cure rate of thermosetting plastics. With this instrument, flow was evaluated for filled and unfilled epoxies, phenolics, silicones, and polyesters. The oscillating disk rheometer is capable of about 95% precision and yields a continuous record from initial to final stiffness during thermosetting. In addition to being a research tool, the oscillating disk rheometer provides a means of rapid quality control testing of thermosetting plastics. (auth)

**21599** (MLM-1599) DETERMINATION OF LITHIUM HYDROXIDE BY CONTROLLED-CURRENT COULOMETRY. Gillette, R. K.; Greenlee, K. L.; Bohl, D. R.; Sellers, D. E. (Mound Lab., Miamisburg, Ohio). Mar. 26, 1969. Contract AT-33-1-GEN-53. 11p. Dep. CFSTI.

A controlled-current coulometric procedure was developed for determination of lithium hydroxide with internal generation of hydrogen ions in an electrolyte solution. The procedure eliminated the preparation, standardization, and storage of standard solutions necessary for volumetric acid-base titrations and is readily adaptable to automation. An electronic, solid-state controlled-current coulometer was used to integrate the titration current. The excellent stability and high sensitivity of the instrument are features required for determining small amounts of substances by controlled-current coulometric titration. Samples containing 25 to 1000 $\mu$g/ml of lithium hydroxide were analyzed with an average standard deviation of $\pm 0.6$ $\mu$g. Results indicated that as little as 50 $\mu$g of lithium hydroxide are required to easily titrate solutions containing 25 to 1000 ppM lithium hydroxide. Good results were obtained with excellent reproducibility. Consequently, it should be possible to titrate solutions containing as low as 2 ppM lithium hydroxide with a 25-ml aliquot and an equal volume of electrolyte. (auth)

**21600** (NP-17796) PAST TRENDS AND PRESENT CONDITIONS OF THE POPULATION AND ECONOMY IN ACCELERATOR STUDY AREA. Preliminary Report I. (Real Estate Research Corp., Chicago, Ill.). July 1968. 116p.

For Illinois Dept. of Business and Economic Development, Springfield.

This report is the first Preliminary Report in the Comprehensive Accelerator Impact Study series. The report deals with past trends and current estimates of population, housing, labor force characteristics, industrial employment, non-industrial employment, commuting labor force, and income in the accelerator study area. Sources of information for this report include census information, building permit data and extensive interviewing and surveying in the Study Area. The methodology used to determine the various estimates that appear throughout the report is only mentioned or discussed briefly. A more detailed description of methodology used in deriving the various estimates and projections which appear in the entire Development Impact Study series will be given in Preliminary Report IX, Technical Report on Methodology. (auth)

**21601** (NP-17797(Vol.1)) PROJECTIONS OF THE POPULATION AND ECONOMY WITH AND WITHOUT ACCELERATOR. Preliminary Report V. (Real Estate Research Corp., Chicago, Ill.). Dec. 1968. 71p.

For Illinois Dept. of Business and Economic Development, Springfield.

The purpose of this report is to provide decision-makers and economic planners and developers in the study area with alternative projections of population, housing, labor force, employment and income by county and subareas (townships). Alternative projections have been made because it was believed that the study area's future is multiple—that is, there are alternative futures, not just one. The future of Du Page and Kane counties will be determined, in large part, by the responsiveness of government bodies, developers, and others to the needs and desires of people seeking homes, businesses seeking customers, and industries seeking a profitable place to create things. This responsiveness is partly determined by awareness and partly by capability, by order to obtain a better understanding of the awareness and capability of state and local governments to accommodate growth in Du Page and Kane counties, their developmental responsibilities and trends in the provision of facilities and services were studied. Rather than make one set of economic and population forecasts for the townships in Du Page and Kane counties, alternative forecasts were made based on differing sets of assumptions regarding the awareness of public and private decision-makers to the needs and opportunities likely to be present and their capability of meeting the needs and take advantage of the opportunities. Three sets of projections were made, employing the following basic assumptions: no accelerator; accelerator, maintenance of present policies, and practices; and accelerator and vastly improved way of doing things (both public and private). The alternative sets of projections use different explicitly stated assumptions regarding catalysts for future growth in the study area. Each alternative projection identifies the over-all qualities and quantities of expected change and the spatial distribution of the population and economy within the study area. Each of the three sets of projections was made by five-year intervals to the year 1985. All three projections and the sets of assumptions for each are described. (auth)

**21602** (NP-17797(Vol.2)(Add.)) PROJECTIONS OF THE POPULATION AND ECONOMY WITH AND WITHOUT ACCELERATOR. Preliminary Report V. (Real Estate Research Corp., Chicago, Ill.). Dec. 1968. 111p.

For Illinois Dept. of Business and Economic Development, Springfield.

Addendum I to preliminary report V includes impact studies of Argonne National Laboratory, Oak Ridge National Laboratory, Brookhaven National Laboratory, Stanford Linear Accelerator Center, NASA Manned Spacecraft Center, and John F. Kennedy Space Center. Addendum II includes comparitive studies associated with trends in population, age, total household, single-and multi-family households, labor force, industrial employment, manufacturing employment and non-industrial employment. (B.G.D.)

**21603** (NP-17798) CHARACTERISTICS OF THE ACCELERATOR WHICH ARE MOST RELEVANT TO DEVELOPMENT IMPACT. Preliminary Report IV. (Real Estate Research Corp., Chicago, Ill.). July 1968. 67p.

For Illinois Dept. of Business and Economic Development, Springfield.

The nature of this report, the fourth of this series of ten, is to identify the various characteristics of the accelerator's building program and its program of operation that are most relevant to development impact. The impact created by the accelerator has already begun. Design work and land acquisition are underway. Thus, some construction personnel and accelerator employees are working on or near the site; they are living in surrounding communities and doing their shopping in local stores. Just what effect they will have, and what effect increased numbers of them will have on the economy of the area is the overall subject of the entire Accelerator Impact Study. In this memorandum, we examine (1) the characteristics of the accelerator's construction and

operating facilities, (2) the numbers, types and characteristics of employees in both construction and operation phases of the program, and (3) the types of facilities needed in surrounding communities during construction and operation. The quantification of both direct and indirect impact of these characteristics is introduced in this report for further consideration in later reports in the series. (auth)

**21604** (ORNL–4385) MATHEMATICS DIVISION ANNUAL PROGRESS REPORT FOR PERIOD ENDING DECEMBER 31, 1968. Feliciano, Manuel Jr.; Nestor, C. W. Jr. (comps. and eds.) (Oak Ridge National Lab., Tenn.). Mar. 1969. Contract W-7405-eng-26. 116p. Dep. CFSTI.

An annual progress report is presented on mathematics and computer operations and mathematical statistics at ORNL during the period ending December 31, 1968. Topics include mathematical research, computer applications, systems programming, computer operations, and mathematical statistics. (W.H.K.)

**21605** (ORNL-TM–2401) STABLE ISOTOPE CUSTOMER LIST AND SUMMARY OF SHIPMENTS, FY 1968. Keith, Susan C. (comp.) (Oak Ridge National Lab., Tenn.). Feb. 1969. Contract W-7405-eng-26. 29p. Dep. CFSTI.

An alphabetical list of domestic and foreign customers with the stable isotopes purchased during the fiscal year is given. A tabulation of the shipments, quantities, and dollars for domestic, foreign, and project categories for each isotope is presented and the total figures for each isotope are included. Also, the total number of stable-isotope loan shipments and quantities is listed. (auth)

**21606** (SC-RR–68-546) CATHODE RAY TUBE COLOR PLOTTING. Fisk, C. J. (Sandia Labs., Albuquerque, N. Mex.). Jan. 1969. 16p. Dep. CFSTI.

Modifications to a commercially available cathode ray tube plotter (Stromberg Carlson 4020) have been made by Sandia to allow direct-color film exposure. Hardware of the plotter was modified and three unused programming commands were utilized to allow color control by the user in the FORTRAN programming language. The user can thus produce either color movies or slides. An additional facility to reduce programming effort has been provided so that slides can be generated merely by entering data, thus allowing nonprogramming personnel to use the system easily. (auth)

**21607** (SC-RR–69-55) FIELD FRINGING AROUND THE INSULATING GAP IN GUARD RING QUARTZ GAUGES. Freeman, J. R. (Sandia Labs., Albuquerque, N. Mex.). Jan. 1969. 38p. Dep. CFSTI.

The effect of electric field fringing around the insulating gap of a guard ring quartz gage for observing shock waves in the stress region of tens of kilobars with a time resolution of a few nanoseconds was investigated by numerically solving a series of boundary value problems corresponding to different stress front positions. The method of successive over-relaxation with a continuously corrected acceleration factor was used, incorporating a multi-segment, variable density mesh. The calculations indicate that no significant deviations from the one-dimensional model can be attributed to guard ring field fringing. This result was obtained for stress pulse durations both longer and shorter than the stress transit time through the gage, and for wide and narrow guard ring gaps. (auth)

**21608** (SLAC–95) PEG: INTERACTIVE LEAST SQUARES DATA-FITTING PROGRAM. Smith, Lyle B. (Stanford Linear Accelerator Center, Calif.). Feb. 1969. Contract AT(04-3)-515. 87p. Dep. CFSTI.

An interactive program for data-fitting by the method of least squares is discussed in some detail. The program was implemented on an IBM 360/75 and 360/91 with an IBM 2250 Mod II display unit as the man-machine interface. The least squares data-fitting problem is briefly discussed, and a short description of the direct search minimization method which was chosen to handle the nonlinear least squares problems is given. Finally, the displays utilized in the interactive data-fitting process are depicted by photographs of the 2250 screen during operation, and an extensive discussion of the use of the program is given. The program was written in FORTRAN IV for ease of implementation and to achieve some degree of machine independence. (auth)

**21609** (SRRC–14/67) REPORT ON SESSION, ANNUAL, 1965–1966. (Scottish Research Reactor Centre, East Kilbride (Scotland)). Jan. 1967. 17p. Dep.

This report deals with expansion of facilities, approval to set up an isotope geology unit, the bringing into use of the mobile whole body monitor MERLIN (Monitoring Equipment for Radioactivity at Low Level in vivo), and research on the following topics: tritium produced in fission; neutron diffraction; beta emission following fission; neutron capture gamma rays in various materials (B, rare earths, $H_2$); mass spectrometry in radiation chemistry; and vivo activation analysis. An increase in power of the reactor is also discussed. (UK)

**21610** (TID–3751) BIBLIOGRAPHIES OF ATOMIC ENERGY LITERATURE. Issued or in Progress During the Period January–February 1969. (Division of Technical Information Extension, (AEC) Oak Ridge, Tenn.). 10p. Dep. CFSTI.

**21611** (TID–5001(8th Rev.)) SUBJECT HEADINGS USED BY THE USAEC DIVISION OF TECHNICAL INFORMATION. Lanier, Sidney F. (ed.) (Division of Technical Information Extension (AEC), Oak Ridge, Tenn.). Jan. 1969. 268p. Dep. CFSTI.

A subject heading authority used as an information indexing and retrieval tool in preparing indexes to the literature abstracted in Nuclear Science Abstracts (NSA) and in searching these indexes either by manual or machine-assisted methods is presented. (B.G.D.)

**21612** (UCRL–18439) TRIM: A MAGNETOSTATIC COMPUTER PROGRAM FOR THE CDC 6600. Colonias, John S. (California Univ., Berkeley. Lawrence Radiation Lab.). Aug. 29, 1968. Contract W-7405-eng-48. 51p. Dep. CFSTI.

The capabilities and limitations of the magnetostatic computer program TRIM, with particular emphasis on the usage of this program, preparation of input data, and general operating characteristics applicable to the CDC 6600 Computer System are described. (auth)

**21613** (UCRL–50557) TURBULENCE AS A MOTION OF A WIENER SPACE. Neuman, M. (California Univ., Livermore. Lawrence Radiation Lab.). Dec. 4, 1968. 29p. Dep. CFSTI.

A straightforward application of Wiener's technique to statistical hydrodynamics leads to what is essentially a functional Lagrange representation of the equations of motion. In this article a functional Euler representation is introduced which seems more appropriate to the problem of turbulence. The equations of motion are transcribed in the new representation. Also the hypothesis is put forward that turbulence is, in a sense, a quasi-ergodic motion in the Wiener measure space, and some analytic consequences are deduced from this hypothesis. These are represented as differential constraints on the expansion coefficients of the velocity in terms of Wiener-Hermite functionals. (auth)

**21614** (UCRL–50568) ECSBIB: A COMPUTER PROGRAM FOR MAINTAINING TECHNICAL BIBLIOGRAPHIES. Thompson, David W. (California Univ., Livermore. Lawrence Radiation Lab.). Jan. 11, 1969. 22p. Dep. CFSTI.

ECSBIB is a computer program for creating and maintaining a technical bibliography, using magnetic tape storage. It is applicable to any bibliography that has become cumbersome to maintain because of size. The program produces a comprehensive report, including a unique list of bibliographic sources, complete lists of references sorted alphabetically and numerically, and author list with associated reference numbers. (auth)

**21615** (UCRL–50574) NATURAL FREQUENCIES FOR A RECTANGULAR BASIN ON A BETA-PLANE. Crowley, W. P. (California Univ., Livermore. Lawrence Radiation Lab.). Jan. 16, 1969. 13p. Dep. CFSTI.

The natural frequencies for barotropic flow in a rectangular basin on a beta-plane for both the free-surface and the fixed-surface cases are determined as functions of the aspect ratio of the basin and the Coriolis parameter by two different methods. (auth)

**21616** CAHIERS DU DROIT DE L'ENERGIE ATOMIQUE. I. (Specifications of Atomic Energy Regulations. I.). Paris, Centre d'Etudes du Droit de l'Energie Atomique, 1968. 198p.

Six articles on atomic energy law are compiled. The articles deal with progress toward a unified nuclear law, future prospects for scientific cooperation in the framework of the European Community, Euratom and the nuclear non-proliferation treaty from a legal viewpoint, implementation of the first international convention on civil responsibility in the realm of nuclear energy, law projects relative to civil responsibility in the nuclear energy region, and problems and prospects for nuclear navigation in Italy. A bibliography is presented on literature published in 1967 on nuclear energy law. An abstract is given of each book. 96 references. (J.S.R.)

**21617** PROGRESS IN AERONAUTICAL SCIENCES. VOLUME 9. Kuechemann, D.; Carriere, P.; Rott, N.; Etkin, B.; Smolderen, J.; Wuest, W.; Fiszdon, W.; Tani, I. (eds.). New York, Pergamon Publishing Company, 1968. 477p. $20.00.

Five articles are included. A separate abstract was prepared for one article on MHD generators. The other subjects covered are: a general procedure for the measurement of the vibrational characteristics of weakly damped linear structures; a numerical method of characteristics for three-dimensional supersonic flow; thermal characteristics of boundary layers and a practical calculation method for heat transfer in hypersonic flow; and an analysis of some performance aspects of various types of aircraft designed to fly over different ranges at different speeds. (M.H.R.)

*For an abstract of the individual paper see: 20748.*

# NOTICE

A title page for Volume 23, Numbers 7–12, is included at the back of this issue for use in binding those issues.

# CORRECTIONS

NSA Vol. 21, No. 10, Abst. No. 15980, line 7 should read: forschungszentrum, Karlsruhe, Ger.) Nukleonik, 8: 363-5

NSA Vol. 23, No. 1, Abst. No. 2127, line 1 should read: (RT/FI-(68)27) KINETICS OF TWO LOOSELY

NSA Vol. 23, No. 5, Abst. No. 8567, line 2 should read: CRITICAL CURRENT IN SUPERCONDUCTING Nb-Zr ALLOYS.

NSA Vol. 23, No. 6, Abst. No. 9302, line 41 should read: POTASSIUM FLUORIDES—KF–LiF–NaF, separation of

NSA Vol. 23, No. 6, Abst. No. 9302, line 49 should read: SODIUM FLUORIDES—KF–LiF–NaF, separation of hydro-